This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LANE MEDICAL LIBRARY STANFORD
2 45 0172 2896

PREFACE TO THE FIRST EDITION.

THE aim which I have steadily kept before me throughout the following pages, when dealing with the causes, symptoms, and treatment of Diseases of the Ear, and the treatment of the Affections of the Nose and Pharynx which conduce to aural disease, has been, before all things, to be of service to the members of the Profession who feel themselves drawn to give special attention to a department the importance of which, I regret to say, is still only partially recognised.

It will be noted in the course of the work that where I have felt compelled to differ from justly respected authorities, I have fully set forth my reasons for so doing; and where I depart from traditional methods of treatment I have, by a sufficiency of detail, I trust, made my meaning and method clear.

I gladly avail myself of these few introductory lines to make my acknowledgments to Mr. RICHARD LAKE for the sections of Aural Polypi, and to Dr. FREDERIC HEWITT for valuable suggestions with respect to the administration of anæsthetics.

In sending forth my work I cherish the hope that it may be found materially to aid all earnest workers in the Profession.

T. MARK HOVELL.

105, HARLEY STREET, W.,
August, 1894.

A TREATISE

ON THE

DISEASES OF THE EAR

CHAPTER II.

PAGE

THE SOUND-CONDUCTING APPARATUS (*continued*).

THE MIDDLE EAR OR TYMPANUM . . . . 21—68

Position, Contents, and Boundaries of Tympanum, 21. Membrana Tympani, its Size, Direction, Colour, and Structure, 22. External, Middle, and Internal Layers, 24. Shrapnell's Membrane, 26. Vessels and Nerves, 26. Inner Wall of Tympanum, 27. The Posterior Wall; the Anterior Wall; the Roof or Cranial Wall; the Floor or Jugular Wall, 29. Apertures of Communication with other Parts, 30. Dimensions of the Tympanum, 31. The Attic of the Tympanum, 31. Functions of the Membrana Tympani, 34. The Ossicles, 35. Their Ligaments and Articulations, 37. Movements of the Ossicles, 38. Muscles of the Tympanum, the Tensor Tympani, and the Stapedius, 40. Lining Membrane of the Tympanum, 45. The Tympanum in the Fœtus, 48. Vessels and Nerves of the Tympanum, 48. The Eustachian Tube, its Osseous, Cartilaginous, and Membranous Portions, 50. Mucous Membrane, 54. The Pharyngeal Opening, 55. The Eustachian Tube in Children, 56. Muscles, Fasciæ, and Ligaments connected with the Tube, 56. Vessels and Nerves, 58. Functions of the Tympanum and Eustachian Tube, 59. The Mastoid Portion of the Temporal Bone; the Lateral and Sigmoid Sinuses, 61. The Mastoid Antrum, as a Portion of the Tympanum, 63. The Mastoid Cells, Description and Function, 63.

CHAPTER III.

THE EXAMINATION OF PATIENTS SUFFERING FROM AURAL AFFECTIONS. GENERAL SYMPTOMS AND CAUSES . . 69—77

Investigation of History of Case, 69. Points to be Ascertained, 70. Influence of Age, Occupation, and Surroundings, 70. Duration of Symptoms, 71. Injuries as a Cause, 72. Previous Diseases, 72. Hereditary Predisposition, 73. Pain as a Symptom, 73. Discharges from the Ear, 74. Vertigo, 75. Subjective Auditory Sensations, 75.

CHAPTER IV.

THE EXAMINATION OF THE EAR AND DETERMINATION OF THE HEARING-POWER . . . . 78—105

Examination of the Ear, 78. Sources of Light, 78. Mirrors, 81. Use of Specula, 83. Brunton's Auriscope, 83. Other Forms, 85. Methods of Using, 86. Points to be Noticed, 87. The Membrana Tympani, Normal Appearance, 87. Parts Seen through it, 88. The Cone of Light, 88.

PAGE

Mobility of Membrane, 89. Use of Siegle's Speculum, 89. Division of the Membrane into Quadrants, 90. Determination of Hearing-Power, 91. Use of the Watch, 91. Formula for Registering Hearing-Power, 92. Politzer's Acoumeter, 93. Hughes' Sonometer, 95. Testing with High Notes, 95. Galton's Whistle, 95. Speech as a Test of Hearing, 96. Methods to be Adopted, 97. Whispered Speech, 97. The Tuning-Fork, 98. Tests for Bone-conduction, 99. Use of the Watch, Tuning-Forks, 99. Weber's Experiment, 99. Tuning-Forks with Clamps, 100. Rinne's Experiment, 102. Value of Tests, 103. Gruber's Modification, 103. Gellé's Method, 104.

CHAPTER V.

EXAMINATION OF THE NOSE, PHARYNX, AND EUSTACHIAN TUBES 106—143

Frequent Dependence of Diseases of Middle Ear upon Morbid Processes in Pharynx and Nares, 106. Importance of Examining these Parts and Eustachian Tube, 106. Requisites for Anterior Rhinoscopy, 107. Parts Visible, 107. Examination of Mouth, Fauces, and Lower Part of Pharynx, 108. Parts Seen, 108. Posterior Rhinoscopy, 109. Parts brought into View, 112. Pharyngeal Openings of the Eustachian Tubes, 113. Digital Examination of the Naso-Pharynx, 114. Structures Distinguishable, 115. Examination of the Eustachian Tubes, 115. Tests of their Permeability, 115. Valsalva's Method, 116. Politzer's Method, 117. The Author's Bag for Injecting Air, 118. Description of Details, 118. Distension of Cheeks, 118. Modifications suggested by Lucae and Gruber, 119. Use of Auscultation Tube, 120. Precautions in Employing Politzer's Method, 121. Occasional Unpleasant Symptoms, 121. Effect Produced by Politzer's Method, 122. The Eustachian Catheter, Forms and Description of the Instrument, 122. Length, Gauge, and Curve of the Catheter, 123. Author's Plan for Uniformity of Measurements, 123. Vulcanite and Silver Catheters, 125. Bag for Injecting Air, 126. Introduction of the Eustachian Catheter, 127. Modes of Overcoming Difficulties, 130. Use of Air-Bag, 131. Other Methods of Introducing Catheter, 132. Plans Recommended by Frank and Gruber, 132. Indications that the Catheter is in Proper Position, 133. Obstacles to the Introduction of the Eustachian Catheter, 133. Methods of Dealing with them, 133. Emphysema sometimes produced, 134. Sounds produced during Injection of Air, 135. Causes of Absence of Sounds, 136. Action of Stream of Compressed Air upon the Eustachian Tube and Tympanum,

PAGE

136. Removal of Exudation, 137. Improvement of Hearing-Power, 138. Action in Cases of Perforation of the Membrane, 138. Comparative Value of the Various Methods of Inflating the Tympanum, 138. Passage of Bougies along the Eustachian Tube, 140.

CHAPTER VI.

METHODS OF TREATMENT . . . . 144—161

Syringing the Ear, 144. Method of Performing, 147. Symptoms occasionally Caused, 148. Application of Heat and Cold to the Ear, 149. The local Abstraction of Blood, 151. Massage, 152. The Introduction of Medicated Solutions into the Meatus, 154. The Insufflation of Remedies in the Form of Powders, 155. The Air-Douche and Injections through the Eustachian Tube, 156. The Injection of Vapours and Gases through the Eustachian Tube, 159. Constitutional Treatment, 160.

CHAPTER VII.

DISEASES OF THE EXTERNAL EAR.

MALFORMATIONS OF THE AURICLE AND EXTERNAL MEATUS. . 162—168

CHAPTER VIII.

DISORDERS OF THE SECRETION IN THE AUDITORY MEATUS—ACCUMULATION OF CERUMEN—KERATOSIS OBTURANS. . 169—176

CHAPTER IX.

INJURIES OF THE AURICLE—BURNS AND SCALDS—FROSTBITES . 177—180

CHAPTER X.

OTHÆMATOMATA, OR BLOOD-TUMOURS OF THE AURICLE . . 181—185

CHAPTER XI.

PERICHONDRITIS OF THE AURICLE 186, 187

CHAPTER XII.

HERPES OF THE AURICLE—ECZEMA OF THE AURICLE. . . . 188—194

CHAPTER XIII.

CIRCUMSCRIBED OR FURUNCULAR INFLAMMATION OF THE EXTERNAL MEATUS . . . . 195—202

CHAPTER XIV.

PAGE
DIFFUSE INFLAMMATION OF THE EXTERNAL AUDITORY MEATUS . 203—207

CHAPTER XV.

CROUPOUS AND DIPHTHERITIC INFLAMMATION OF THE EXTERNAL AUDITORY MEATUS . . . . 208—210

CHAPTER XVI.

PARASITIC INFLAMMATION OF THE EXTERNAL MEATUS . . . . 211—217

CHAPTER XVII.

SYPHILITIC AFFECTIONS OF THE EXTERNAL EAR . . . . 218—221

CHAPTER XVIII.

NEW FORMATIONS OF THE AURICLE AND EXTERNAL MEATUS . 222—238

Angioma, 222. Fibroma, 224. Cysts, 224. Sarcoma, 225. Epithelioma, 227. Lupus, 228. Osteomata, 229. Exostoses, 230. Symptoms and Treatment, 231. Case of Exostosis Removed by Drill and Screw, 236.

CHAPTER XIX.

FOREIGN BODIES IN THE EAR . . . . 239—248

Classification of Foreign Bodies: Vegetable, Animal, Mineral, 239. Symptoms caused by Insects in Meatus, 240. Treatment, 241. Symptoms caused by Non-living Bodies, 242. Reflex Symptoms, 242. Symptoms often Aggravated by Attempts at Removal, 243. Diagnosis, 243. Prognosis, 243. Treatment, Various Methods and Precautions, 244. Substances Liable to be Swollen by Moisture, 246. Various Instruments for Extracting Foreign Bodies from Meatus, 246. Course to be Pursued when Extraction by Ordinary Methods Impossible, 248. Partial Separation of Auricle, 248.

CHAPTER XX.

AFFECTIONS OF THE MEMBRANA TYMPANI . . . . . . 249—265

Injuries of the Tympanic Membrane, 249. Indirect and Direct Causes, 249. Symptoms, 250. Subjective Sensations, 251. Alterations in Hearing-Power, 251. Objective Symptoms, 252. Rupture of the Membrane from Sudden Condensation of Air, 253. Dr. Snell on Caisson Disease, 255. Mechanical Injuries, 256. Rupture

PAGE

of the Membrane by *Contre-Coup*, 257. Prognosis, 258. Treatment, 259. Inflammation of the Membrana Tympani or Myringitis, 259. Symptoms, 260. Abscesses in the Membrane, 261. Formation of Vesicles, 261. Diagnosis, 262. Prognosis, 262. Treatment, 262. Chronic Inflammation of the Membrana Tympani, 264. Causes, 264. Symptoms, 264. Course and Treatment, 265.

CHAPTER XXI.

DISEASES OF THE NOSE, PHARYNX, AND NASO-PHARYNX, CONNECTED WITH DISEASES OF THE MIDDLE EAR . . . 267—322

Influence of Diseases of Nose and Naso-Pharynx on Condition of Tympanum, 268. Acute Nasal Catarrh, 268. Causes and Symptoms, 269. Extension to Eustachian Tubes, 269. Objective Appearances, 269. Treatment, 270. Chronic Catarrh of the Naso-Pharynx, 270. Causes and Anatomical Appearances, 271. Condition of the Mucous Membrane, 271. The Secretions, 272. Symptoms Caused by Swelling of the Mucous Membrane, 272. Nervous Disorders, 273. Course and Changes sometimes produced in Mucous Membrane, 273. Ulcerative Processes, 273. Connection between Chronic Naso-Pharyngeal Catarrh and Aural Diseases, 273. Treatment, 274. Local Applications, 274. The Nasal Douche, 275. Spray Apparatus, 275. The Syringe, 277. Method of Applying Solutions to the Nares, 278. Inhalation, 278. Ointments, 278. Caustics in Solution, 279. Insufflation of Fine Powders, 279. Nasal Bougies, 281. The Galvano-Cautery, 281. Chemical Caustics, 283. Treatment of Ozæna, 283. Treatment of Enlargement of Posterior Extremity of Inferior Turbinated Body, 284. Treatment of Nasal Polypus, 285. Treatment of Enlarged Tonsils, 288. Granular Pharyngitis, 295. Removal of Tip of Uvula, 297. Morbid Growths in the Naso-Pharynx and their Treatment, 298. Measures for Restoring the Functions of the Muscles of the Tubes, 299. Adenoid Growths, 300. The Pharyngeal Tonsil, 300. Literature on the Subject of Adenoid Growths, 300. Their Anatomical Structure, 301. Etiology, 301. Symptoms, Subjective and Objective, 302. Disorders of Middle Ear Resulting from these Growths, 303. Methods of Examination, 306. Digital Examination, 306. Inspection with the Mirror, 307. Diagnosis, 307. Treatment, 308. General Anæsthesia in Nasal and Naso-Pharyngeal Operations, 310. Cases necessitating General Anæsthesia, 310. Preparation of the Patient, 311. Selection of the Anæsthetic, 311. Posture of the Patient, 312. Administration of the

PAGE

Anæsthetic, 314. Additional Appliances, 315. Management of the Patient after the Administration, 316. Method of Removing Adenoid Growths, 318.

CHAPTER XXII.

AFFECTIONS OF THE EUSTACHIAN TUBE . . . . . . 323—332

Extension of Morbid Processes through the Eustachian Tube, 323. Injuries to the Eustachian Tube, 324. Foreign Bodies, 324. Inflammation of the Eustachian Tube, 325. Anatomical Appearances, 325. Symptoms, 326. Examination of the Throat and Ear, 326. Treatment, 327. Constrictions of the Eustachian Tube, 328. Diagnosis, 329. Complete Atresia, 329. Undue Patency, 330. Ulceration of the Eustachian Tube, 330. Diphtheria, Small-pox, Tuberculosis, and Syphilis, 331. Treatment of Constrictions, Abnormal Patency, and Ulceration, 331.

CHAPTER XXIII.

DISEASES OF THE TYMPANIC CAVITY—INTRODUCTION . . . 333—336

CHAPTER XXIV.

ACUTE CATARRH OF THE MIDDLE EAR . . . . . 337—354

Frequency and Causes of the Disease, 337. Affections of the Throat, 338. Part Played by Micro-organisms, 339. Channels of Access, 341. Morbid Appearances, 342. Subjective Symptoms, 343. Impairment of Hearing, 343. Subjective Sensations, 344. Autophony, 344. Increased Temperature, 344. Objective Symptoms, 344. Appearance of the Meatus and Membrane, 345. Effects of the Air-Douche, 347. Auscultation and Sounds Heard, 347. Diagnosis, 347. Prognosis, 348. Treatment, 348. Attention to the Naso-Pharynx, 349. Relief of Pain, 349. The Air-Douche, 349. The Operation of Paracentesis, 351. Spontaneous Perforation and its Treatment, 353. Treatment of Adenoid Growths and of Enlarged Tonsils, when Present, 354.

CHAPTER XXV.

CHRONIC CATARRH OF THE MIDDLE EAR . . . . . . 355—366

Chronic Catarrh of the Tympanum, 355. Frequency and Forms, Catarrhal and Adhesive, 355. Causes, 356. Affections of the Eustachian Tube, 356. Anatomical Appearances, 356. Subjective Symptoms, 357. Deafness, Noises in the Ear, Giddiness, Autophony, Paracusis, etc., 358.

PAGE

Objective Appearances, 359. Condition of Membrana Tympani, 359. Use of the Catheter and Air-Douche, 360. Effects on Appearances, 361. Perforation of the Membrane, 361. Course, 362. Diagnosis and Prognosis, 362. Treatment, 363. Attention to State of Naso-Pharynx, 363. The Air-Douche, Politzer's Method, the Catheter, 364. Chloride of Ammonium Vapour and Remedies in Fluid Form, 364. The Use of Siegle's Speculum, 365. Paracentesis and Plicotomy, 365. General Treatment of Chronic Middle-Ear Catarrh, 365.

CHAPTER XXVI.

CHRONIC ADHESIVE CATARRH OF THE MIDDLE EAR—OTITIS MEDIA CATARRHALIS SICCA—SCLEROSIS OF THE MIDDLE EAR . 367—402

Nature of the Disease, 367. Origination and General Consequences, 368. Pathological Appearances, 368. Causes, 371. Symptoms, 371. Impairment of Hearing, 371. Subjective Sensations, 372. Hyperæsthesia Acustica, 372. Paracusis, 373. Objective Appearances, 373. The Membrana Tympani, 373. Contraction of Tensor Tympani Muscle, 374. Condition of the Naso-Pharynx and Eustachian Tubes, 375. Testing the Hearing-Power, 376. Course and Termination, 377. Diagnosis, 379. Prognosis, 381. Treatment, 382. Attention to Naso-Pharynx, 382. The Air-Douche, 382. Application of Remedies to the Tympanum, 383. Solutions of Pepsin and Papain, 385. Rarefaction of Air in the Meatus, 386. Politzer's Plan, 387. Lucae's Spring Pressure-Probe, 387. Hommel's Method, 387. Treatment of the Tinnitus, 388. The Eustachian Tubes, 389. General Hygienic Rules, 389. Operations Proposed, 390. Removal of Tympanic Membrane and Ossicles, 390. Establishment of an Opening in the Membrane, 393. Division of the Posterior Fold of the Tympanic Membrane, 394. Division of the Anterior Ligament of the Malleus, 396. Multiple Incisions into the Tympanic Membrane, 396. Division of the Tendon of the Tensor Tympani Muscle, 398. Indications for Operation and Various Methods, 399. Results, 401.

CHAPTER XXVII.

ACUTE SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR . . 403—422

Nature of the Disease, 403. Causes, 403. Micro-Organisms, 404. Frequency as affected by Age, Sex, Climate, etc., 405. Reasons for Frequency in Young Subjects, 406. Symptoms, 407. Subjective, as Pain, Impairment of Hearing, etc., 407. Objective, Changes in Tympanic

PAGE

Membrane, 408. Perforation, Signs of, and Methods of Discovering, 409. Character of Secretion, 411. Course and Results, 412. Diagnosis, 414. Prognosis, 415. Treatment, 416. Antiphlogistics, 416. Paracentesis, 417. The Air-Douche, 419. Local Remedies, 420. Treatment of Cases of Spontaneous Perforation, 421. Mastoid Complications, 422.

CHAPTER XXVIII.

CHRONIC SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR . 423—459

Statistics showing Frequency of the Complaint, 423. Morbid Appearances in the Tympanic Cavity and Membrane, 424. Caries of the Ossicles, 426. Suppuration in the Upper Tympanic Spaces, 426. The Eustachian Tube, 427. Causes, Influence of Age, Sex, etc., 427. Subjective Symptoms, 428. Impairment of Hearing, Tinnitus, Giddiness, 429. Pain as a Symptom, 429. Evidences of Nervous Disorders, 430. Objective Symptoms, 430. Discharges from the Ear, 430. Micro-Organisms, 431. Condition of the Membrana Tympani, 432. Perforations, their Size, Form, etc., 433. Condition of Tympanum, 435. Portions and Structures Visible through a Perforation, 435. Perforation of Shrapnell's Membrane, 435. Suppurative Processes in the Attic, 436. Course and Results of Chronic Middle-Ear Suppuration, 439. Diagnosis of Perforations, 440. Prognosis, 442. Treatment, 444. Various Methods of Cleansing the Middle Ear, 444. The Syringe, Inflation, Enlargement of the Opening, 444. Aspiration, Condensation of Air, Dry Cleansing, 448. Use of Antiseptics, 450. Boric and Carbolic Acids, etc., 452. Caustics, Nitrate of Silver, 453. Astringents, 455. Gelatin Bougies, 456. Constitutional Remedies, 457. Methods of Improving the Hearing-Power, 457.

CHAPTER XXIX.

CHANGES IN THE MEMBRANA TYMPANI IN VARIOUS AFFECTIONS OF THE EAR . . . . 460—483

Cicatrisation, 460. Persistent Perforation of the Tympanic Membrane, 463. Appearances and Consequences, 464. Artificial Substitutes, 466. Method of Determining Effect of Closing a Perforation, 466. Treatment of Perforations, 467. Attempts to Produce Cicatrisation, 467. Myringo-Plastic Operations, 468. Artificial Tympanic Membrane, 469. Appliances devised by Yearsley, Toynbee, Gruber, Hartmann, and Others, 469. Rules to be Adopted, 472. *Modus Operandi* of such Appliances, 472. Indications for Employment of Artificial Membranes, 473. Cal-

PAGE

careous Deposits in the Membrana Tympani, 474. Appearances, 475. Symptoms and Treatment, 475. Thickening of the Tympanic Membrane, 476. Atrophic Processes in the Membrane, 477. Adhesions between the Membrane and the Wall of the Tympanum, 478.

CHAPTER XXX.

CONSEQUENCES AND SEQUELÆ OF CHRONIC MIDDLE-EAR SUPPURATION . . . . 484—491

Formation of Cholesteatomatous Masses in the Tympanic Cavities, 484. The Growth of Polypi, 484. Caries and Necrosis of the Temporal Bone, 484. Extension of Inflammation to the Mastoid Process and Cells, 484. Cholesteatoma of the Tympanum, Nature and Pathology, 485. Theories Advanced by Tröltsch, Habermann, and Politzer, 486. Symptoms and Consequences, 488. Diagnosis, 489. Prognosis, 489. Treatment, 489.

CHAPTER XXXI.

POLYPI OF THE EAR . . . . 492—509

Classification of Polypoid Growths, 492. Mucous Polypi or Granulation Tumours, 492. Fibrous Polypi, 493. Angio-Fibromata, 493. Myxomata, 495. Relative Frequency of Various Forms, 495. Etiology, 495. Chronic Middle-Ear Suppuration, 495. Sex and Age, 497. Seat of Origin, 497. Number of Polypi, 498. The Pedicle, 498. Size and General Conformation of Aural Polypi, 498. Symptoms, Subjective and Objective, 499. Consequences which may Result, 500. Development and Progress of the Growths, 500. Diagnosis, 500. Polypi of the Tympanum, with the Membrane Intact, 502. Treatment, 502. Operative and by Application of Remedies, 503. Removal by the Snare, 503. Politzer's Knife, 504. The Use of Scoops and Crushing Forceps, 505. The Galvano-Cautery, 505. Caustic and Astringent Applications, 506 Acids, 507. Alcohol, Cases for which Adapted, 508. Acetate of Lead, 509.

CHAPTER XXXII.

CARIES AND NECROSIS OF THE TEMPORAL BONE . . . . 510—526

Causes, 510. Cases due to Injuries, 510. Chronic Middle-Ear Suppuration, 511. Constitutional Disorders, 511. Parts most often Involved, 511. Varying Extent of the Processes, 511. Caries of the Ossicles, 512. Necrosis, 512. Subjective Symptoms, 513. Objective Symptoms, 514. Symptoms of Lesions of the Facial Nerve, 514. Paralysis,

PAGE

514. Perversions of Taste, 515. Character of the Discharge, 516. Examination with a Probe, 516. Course, 517. Diagnosis and Prognosis, 517. Bezold's Statistics, 518. Possible Multiplicity of Complications, 519. Treatment, 519. Special Measures for dealing with Caries and Necrosis of the Ossicles, 521. Removal of the Tympanic Membrane and of the Ossicles through the Meatus, 522. Indications for and Details of the Operation, 522. Subsequent Treatment, 523. Possible Accidents, 524. Treatment of Chronic Suppuration in the Attic, 524. Stacke's Method, 524. Treatment of Necrosis of the Temporal Bone, 526.

CHAPTER XXXIII.

AFFECTIONS OF THE MASTOID PROCESS . . . . 527—556

Variations in the Mastoid Cells, 527. Inflammation of the Mastoid Process, 528. Mastoid Periostitis, 528. Inflammation of the Mastoid Cells, 530. Acute and Chronic Forms, 530. Causes and Morbid Appearances, 532. Symptoms and Course, 533. Caries and Necrosis of Mastoid Process, 535. Course and Consequences, 536. Prognosis, 537. Treatment, 537. Operation in Acute Suppuration in Mastoid Process, 538. Indications for Operations in Chronic Suppuration, 539. Various Conditions of the Surface of the Bone and of the Subjacent Tissue, 542. Anatomical Relations of the Mastoid Process, 543. Summary of Indications and Objects of the Operation, 543. Details of the Operation, 544. Preparation of the Patient, 544. Instruments Required, 544. Position of Patient, 545. The Operation, 545. Exposure of the Attic and of the Mastoid Cells, 548. Formation of a Flap to Line the Cavity, 549. Mr. Ballance's Grafting Operation, 551. Accidents and Complications which may occur during the Operation, 553. Results and Prognosis, 554. Prospect as to Hearing-Power, 555.

CHAPTER XXXIV.

CRANIAL AND OTHER COMPLICATIONS OF MIDDLE-EAR SUPPURATION . . . . 557—592

Extension of Morbid Processes to Intracranial Structures, 557. Number of Cases due to Middle-Ear Suppuration, 558. Relative Frequency of the various Intracranial Complications, 558. Anatomical Conditions facilitating Extension of Morbid Processes from the Tympanum, 559. Causes of the Intracranial Lesions, 560. Micro-organisms,

PAGE

561. Cerebral Meningitis, 561. Various Forms, Pachymeningitis and Lepto-meningitis, 562. Morbid Anatomy, 562. Extradural and Subdural Abscesses, 562. Symptoms, 563. Diagnosis, 565. Treatment, 565. Cerebral Abscess, Development and Symptoms, 566. Temperature, 568. Seat of Abscess, 568. Question as to Multiplicity, 569. Stages of the Morbid Process, 570. Appearances, 570. Terminations, 571. Diagnosis, 571. Treatment, 572. Operations, 573. Phlebitis and Thrombosis of the Sigmoid Sinus and Jugular Vein, 576. Stages in Process and Sources of Infection, 577. Results of Thrombosis, 578. Symptoms, 579. General, 579. Pulmonary, Abdominal, and Meningitic, 580. Local Symptoms, 580. Course, 582. Diagnosis, 582. Treatment, 583. Pyæmia from Aural Disease without Sinus Phlebitis, 586. Symptoms, 586. Diagnosis, 587. Prognosis, 587. Treatment, 588. Ulceration of the Carotid Artery, 588. Conditions under which it occurs, 589. Symptoms, 589. Diagnosis, 590. Treatment, 590. General Tuberculosis and Tubercular Meningitis as Results of Ear Disease, 590.

CHAPTER XXXV.

LOCAL AND GENERAL AFFECTIONS LIABLE TO CAUSE DISORDERS OF HEARING . . . . 593—634

Two Principal Classes, 593. Extension of Morbid Processes and Localisation of Specific Micro-organisms in Ear, 593. Cerebral Anæmia and Hyperæmia, 594. Cerebro-spinal Meningitis, 595. Lesions of Cerebral Blood-vessels, 597. Lesions of the Psycho-acoustic Centre, 597. Acute Hydrocephalus, 598. Tumours of the Brain, 598. Spinal Diseases, 599. Croup, Diphtheria, and Scarlatina, 600. Measles, 607. Mumps, 610. Influenza, 614. Typhus, Typhoid, and Small-pox, 620. Malaria, 625. Diabetes, 627. Tuberculosis, 628. Syphilis, 632.

CHAPTER XXXVI.

INJURIES OF THE TYMPANUM—HÆMORRHAGE IN THE TYMPANUM . 635—643

Direct and Indirect Injuries, 635. Causes and Symptoms in both Classes, 636. Escape of Cerebro-spinal Fluid; its Significance, 636. Other Sources of Watery Discharge from the Ear, 637. Openings in Walls of Tympanum and their possible Consequences, 638. Hæmorrhage in the Tympanum, 639. Causes, 639. Symptoms, 640. Treatment, 640. Hæmorrhage with Perforation or Rupture of Membrane, 641. Treatment, 643.

CHAPTER XXXVII.

PAGE

OTALGIA . . . . 644—647

Causes, 644. Symptoms and Treatment, 645.

CHAPTER XXXVIII.

THE ANATOMY AND PHYSIOLOGY OF THE INTERNAL EAR . . 648—667

The Auditory Nerve and the Divisions of the Labyrinth, 648. The Vestibule, 649. The Semicircular Canals, 649. The Cochlea, 650. The Membranous Semicircular Canals, 651. The Cristæ Acusticæ, 652. Otoliths, 653. The Cochlear Nerves, 653. The Scala Media, 655. Corti's Membrane and Organ, 655. The Membrana Basilaris, 656. The Auditory Teeth, 656. Corti's Pillars and Cells, 656. Connections of Cells with Nerves, 657. Reissner's Membrane, 658. Blood-vessels of the Internal Ear, 658. Origin of the Auditory Nerve, 659. Its Connections and Divisions, 659. The Physiology of the Labyrinth, 659. Functions of the Utricle, Saccule, and Semicircular Canals, 660. Flourens' Experiments and their Results, 661. Functions of the Cochlea, 664. The Auditory Area, 666.

CHAPTER XXXIX.

ETIOLOGY, SYMPTOMS, AND DIAGNOSIS OF DISEASES OF THE INTERNAL EAR . . . . 668—693

Comparative Frequency of Diseases of the Labyrinth, 668. Three Classes of Causes: General, Local, and Traumatic, 668. Infectious Diseases, 669. Liability of Auditory Nerve to be Attacked, 669. Nervous Deafness, 669. Morbid Conditions of Organs of Circulation, etc., 670. Effects of Certain Drugs upon the Internal Ear, 671. Diseases of the Brain, 672. Extension of Morbid Processes from the Middle Ear, 672. External Influences, Cold, Shocks, etc., 673. Symptoms of Disorders of the Labyrinth, 674. Deafness, 675. Paracusis, 675. Subjective Sensations, 678. Giddiness and Disorders of Coordination, 678. Nausea and Vomiting, 680. Diagnosis between Diseases of the Labyrinth and those of the Cerebellum, 681. Acoustic Hyperæsthesia, 682. Prognosis, 682. Diagnosis of Diseases of the Labyrinth, 682. Condition of Membrana Tympani and Eustachian Tube, 683. Deafness as a Symptom, 684. Bone-Conduction, 685. Rinne's Test, 686. Drawbacks connected with Rinne's Test, 687. Schwabach's Test, 689. Tests for Duration of Sound-Perception, 689. Testing with High and Low Notes, 690. Galton's Whistle, 691. König's Rods, 691. Summary of Conditions indicative of Disease of Labyrinth, 692.

CHAPTER XL.

PAGE

DISORDERS OF CIRCULATION IN THE LABYRINTH. ANÆMIA—HYPERÆMIA—INFLAMMATION OF THE LABYRINTH . . 694—703

Anæmia of the Labyrinth, Causes and Symptoms, 694. Hyperæmia of the Labyrinth, Causes and Symptoms, 695. Diagnosis, 696. Treatment of Disorders of Circulation, 696. Inflammation of the Labyrinth, 697. Pathology, 697. Question as to Primary Origin, 698. Causes, 699. Gruber's Classification, 699. Exudative and Plastic Forms, 699. Cases due to Diphtheria, 700. Appearances in Cases of Cerebro-spinal Fever, 700. Symptoms, 701. Prognosis, 702. Treatment, 702.

CHAPTER XLI.

CONCUSSION OF THE LABYRINTH—INJURIES TO THE LABYRINTH . 704—709

Causes of Concussion, 704. Symptoms, 704. Diagnosis, 705. Prognosis, 706. Treatment, 707. Injuries to the Labyrinth, 707. Modes of Production, 708. Variations in Results and Appearances, 708. Symptoms, 709. Diagnosis, Prognosis, and Treatment, 709.

CHAPTER XLII.

CARIES AND NECROSIS OF THE LABYRINTH . . . . . . 710—715

Caries of the Labyrinth as a Result of Extension, 710. Necrosis of the Labyrinth, 710. Causes, 711. Symptoms, as Otorrhœa, Pain, Polypous Growths, Disorders of Equilibrium, Subjective Sensations, Loss of Hearing-Power, and Facial Paralysis, 711. Forms of Sequestra, 714. Prognosis, 714. Treatment, 715.

CHAPTER XLIII.

NEW FORMATIONS IN THE LABYRINTH AND CONNECTED WITH THE AUDITORY NERVE—SYPHILIS OF THE LABYRINTH . . 716—724

Primary and Secondary Growths, 716. Epithelioma, 717. Sarcoma and Glioma, 717. Cases of Fibro-sarcoma, 718. Cavernous Angioma, 719. Syphilitic Disease of the Internal Ear, 720. Morbid Appearances, 722. Symptoms, 722. Diagnosis, 723. Prognosis, 723. Treatment, 723.

CHAPTER XLIV.

MÉNIÈRE'S GROUP OF SYMPTOMS . . . . 725—734

Ménière's Account of his First Case, 725. Phenomena of the Attacks and Consequences, 726. Pathology, 727.

PAGE

Flourens' and Crum Brown's Experiments, 727. Dr. Wilks' View, 728. Drs. Woakes' and Gruber's Theories, 729. Effects of Intra-Labyrinthine Tension, 730. Prof. Steiner's Experiments, 731. Diagnosis, 732. Prognosis, 732. Treatment, 733.

CHAPTER XLV.

NEUROSES OF THE AUDITORY NERVE . . . . 735—753

Acoustic Hyperæsthesia, 735. Various Forms, 736. After-Sensations, 737. Neuralgia of the Ear, 737. Hyperacusis of Willis, 737. Acoustic Anæsthesia, 738. Deafness Caused by Occupations, 741. Symptoms of Nervous Deafness, 742. Paracusis Loci, 743. Subjective Auditory Sensations, 743. Peculiarities and Causes, 744. Changes in the Middle and Internal Ear, 745. Effects of Certain Drugs, 745. Reflex Causes, 746. Question as to State of Auditory Nerve, 746. Variations in Sensations, 747. Entotic Noises, 748. Effects of Subjective Sensations, 749. Noises Produced in Throat, 749. Peculiarities in Individuals, 750. Prognosis, 751. Treatment, 751.

CHAPTER XLVI.

ELECTRICITY IN THE TREATMENT OF DISEASES OF THE EAR . 754—758

Physiological Action of Galvanism upon the Auditory Nerves, 754. Sounds Produced, 754. Other Effects, as Pain, Giddiness, etc., 755. Brenner's Experiments, 756. Duchenne's Method, 756. Benedikt's Views, 757. Value of Electricity in the Treatment of Aural Diseases, 757. Weber-Liel's Method, 757. Instruments used by Author, 758.

CHAPTER XLVII.

DEAF-MUTISM . . . . 759—768

Classification of Deaf-Mutes, 759. Statistics, 759. Deaf and Dumb in Great Britain and other Countries, 759. Influence of Sex, 760. Causes of Congenital Deaf-Mutism, 760. Hereditary Transmission and Consanguineous Marriages, 760. Pathological Appearances, 761. Acquired Deaf-Mutism, 762. Age of the Sufferers, 762. Additional Symptoms and Consequences, 763. Diagnosis, 763. Prognosis and Treatment, 764. Importance of Early Instruction, 766. Urbantschitsch's Method, 767.

CHAPTER XLVIII.

PAGE

ARTIFICIAL AIDS TO HEARING . . . . 769—772

Ear-Trumpets and Tubes, 769. Maloney's Otophone, 770. Politzer's Instruments, 770. Rhodes' Audiphone, 771. Paladino's "Fonifero," 771. Desirability of Early Use of Ear-Trumpet, 772.

CHAPTER XLIX.

LIFE-ASSURANCE AND DISEASES OF THE EAR—SIMULATED DEAFNESS—HYGIENE OF THE EAR—MILITARY REGULATIONS . 773—784

Diseases of the Ear Tending to Imperil or Shorten Life, 773. Diseases of the Ear which may be regarded as Unimportant with Reference to Life-Assurance, 774. Decision in Cases of Suppurative Inflammation, 775. Simulated Deafness, 775. Means of Testing, 776. Hygiene of the Ear, 778. Military Regulations in Austria and Prussia with regard to Recruits Suffering from Aural Diseases, 782.

INDEX . . . . 785—808

LIST OF ILLUSTRATIONS.

FIG.		PAGE
1.	Scheme of the Organ of Hearing (Landois and Stirling)	3
2.	The Auricle, showing Acoustic Potentials (Gardiner Brown)	8
3.	Horizontal Section through the External Meatus (Schwalbe)	10
4.	Vertical Section through the External Meatus (Schwalbe.)	12
5.	Section through the Integument of the Cartilaginous Portion of the Meatus (Schwalbe)	16
6.	Outer Surface of the Left Tympanic Membrane of an Adult (Politzer)	22
7.	Internal Surface of the Left Tympanic Membrane (Politzer)	23
8.	Section through a Portion of the Ligamentous Ring of the Tympanic Membrane, and of the Mucous Membrane prolonged from the Cavity (Schwalbe, after Brunner).	27
9.	A and B. The Medial Wall of the Left Tympanum (Schwalbe)	28
10.	The Auditory Ossicles, Right (Landois and Stirling)	35
11.	Diagram showing Movements of Auditory Ossicles (Wagner)	38
12.	The Malleus and Incus (Helmholtz)	40
13.	Section through Malleus and Membrana Tympani, showing some of the Pouches or Recesses of the Tympanic Cavity (Quain's *Anatomy*, after Merkel)	46
14.	Section through Mucous Membrane of Inner Wall of Tympanum of an Adult (Schwalbe, after Brunner)	47
15.	Eustachian Tube and Tympanic Cavity, Right Ear (Politzer)	51
16.	Section through Mastoid Portion of a Man aged 30 (Gruber)	64
17.	Section through Mastoid Process of a Man aged 30 (Gruber)	64
18.	Section through the Mastoid Portion and Tympanum of a Man aged 30 (Gruber)	64
19.	Section through the Mastoid Process of a Man aged 30 (Gruber)	65
20.	Section through the Mastoid, entirely Diploetic, of a Man aged 30 (Gruber)	65
21 and 22.	The Author's Modification of Mackenzie's Rack Movement Gas Lamp	79

FIG. PAGE
23 and 24. The Author's Portable Lamp . . . 80
25. Forehead Mirror and Headband . . . 81
26. Gardiner Brown's Reflector . . . 82
27. Crocodile-Mouthed Forceps . . . 82
28. Imray's Scoop . . . 83
29. Brunton's Speculum, Author's Modification of . . . 83
30. Dalby's Speculum . . . 85
31. Siegle's Pneumatic Speculum . . . 89
32. Politzer's Acoumeter . . . 93
33. Galton's Whistle . . . 96
34. Gardiner Brown's Tuning-Fork, fitted with Tube and Earpiece, as used by the Author . . . 101
35. Muncaster's Nasal Speculum . . . 107
36. Thudichum's Nasal Speculum . . . 107
37. Fränkel's Tongue-Depressor . . . 109
38. Tongue-Depressor used by Author . . . 110
39. Michel's Mirror . . . 111
40. Palate Tractor used by the Author . . . 111
41. Voltolini's Palate Tractor . . . 111
42. White's Self-retaining Palate Tractor . . . 111
43. The Author's Finger-Guard . . . 114
44. The Author's Finger-Guard in Position . . . 115
45. The Author's 10-oz. Air-Bag for Politzer's Inflation, fitted with Gardiner Brown's Nozzle . . . 118
46. Auscultation Tube . . . 120
47. Illustration of Eustachian Catheter with a Curve of 18mm. . . . 123
48. Catheter with Copper Collar . . . 125
49. India-rubber Bag for Injecting Air through a Catheter . . . 126
50. The Author's Revolving Chair . . . 128
51. A Sagittal Section passing to the right of the Nasal Septum (Onodi's *Atlas of the Nasal Cavity and Sinuses*) . . . 129
52. Showing Position of Third and Fourth Fingers of the Left Hand whilst a Catheter is being used . . . 131
53. Vulcanite Cocaine Spray Producer . . . 132
54. Syringe, with Nozzles fitted with Bayonet-Joint . . . 145
55. Gardiner Brown's Ear-Trough . . . 145
56. Ear-Trough in use . . . 146
57. Mayer and Meltzer's Modification of Gardiner Brown's Ear-Trough . . . 147
58. Leiter's Apparatus for applying Cold to the Mastoid Process . 150
59. The Author's Aural Auto-Insufflator . . . 156
60. Malformation of the Auricle (Gruber) . . . 163
61. Spontaneous Othæmatoma occurring in an Idiot (Gruber) . . 183
62. Aspergillus Niger. Heads with Conidia (Siebenmann) . . 211
63. Aspergillus Niger. Four Sprouting Sterigmata (Siebenmann) . 212
64. Aspergillus Fumigatus. Hyphæ and Organs of Fructification (Siebenmann) . . . 213
65. Aspergillus Fumigatus. Typical Specimen of Head (Siebenmann) . . . 213

FIG. PAGE

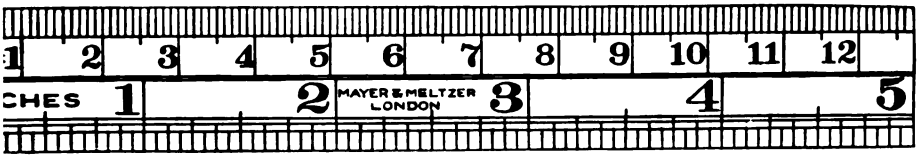
66. Aspergillus Fumigatus. Spherical Heads without Conidia (Siebenmann) 214
67. Aspergillus Fumigatus. Mycelium (Siebenmann) 214
68. Exostoses in Right Meatus 232
69. An Exostosis before Removal 235
70. Self-retaining Guard 236
71. Copper Guard 237
72. The Drill 237
73. The Screw-Extractor 237
74. The Exostosis after Removal 238
75. Hook for the Extraction of Foreign Bodies 247
76. Double Screw for the Extraction of Foreign Bodies . . . 247
77. Ward Cousins' Extractor 248
78. Single Ball Spray-Producer 276
79. Kabierskie's Insufflator 280
80. Fumigator with Spirit Lamp 281
81. The Author's Electrode Handle 282
82. Chromic Acid Carrier 283
83. Swollen Posterior Extremities of Inferior Turbinated Bodies . 285
84. The Author's Modification of Morell Mackenzie's Nasal Snare . 286
85. The Dimensions of the Author's Set of Tonsillotomes . . 288
86. Morell Mackenzie's Modification of Physick's Tonsillotome . 289
87. The Left Tonsil removed from a Man, aged 21 years. . . . 291
88. Diagram showing the Method of applying a Tonsillotome . 292
89. The Author's Uvula Scarifier 294
90. Nunn's Uvula Scissors 297
91. A Boy, aged 14, the Subject of Post-Nasal Growths . . . 304
92. The Author's Post-Nasal Forceps 319
93. Streptococcus Pyogenes; Diplococcus Pneumoniæ; Staphylococcus Pyogenes Aureus; Tubercle Bacillus. (Klein's *Micro-Organisms and Disease*) 340
94. The Right Ear of a Gentleman, aged 56, showing the Tympanum filled with Fluid 346
95. The Appearance of the same Ear after a little Air had been injected 346
96. A small quantity of Fluid in the Right Tympanum . . . 346
97. A Myringotome 351
98. Ward Cousins' Ear-Protectors 366
99. The Author's Tympanic Irrigator 446
100. Wool Forceps 449
101. Delstanche's Masseur 458
102. Perforation after Suppurative Inflammation 464
103. Perforation, with Ossicula in Position 464
104. Perforation, showing Portions of Ossicula 464
105. Perforation, showing Portions of Incus and Stapes . . . 465
106. Membrane, showing a Large Patch of Calcareous Deposit . 465
107. Perforation in Posterior Segment of Tympanic Membrane, showing Disarticulated Stapes. Also another Perforation in front of the Short Process of the Malleus . . . 465

FIG. PAGE

108. Yearsley's Artificial Tympanum 469
109. Introducer for Yearsley's Tympanum 469
110. Toynbee's Artificial Tympanum 470
111. Toynbee's Artificial Tympanum, with Thread instead of Wire . 470
112. Right Tympanic Membrane, with Large Patch of Calcareous Deposit in Anterior and Lower Part 474
113. Granulation Polypus. × 200 493
114. Early Stage of Fibrous Polypus. × 300 494
115. Later Stage of Fibrous Polypus, showing Two Patches of Tissue undergoing Mucoid Degeneration. × 100 494
116. Angio-Fibromatous Polypus. × 25 496
117. Myxomatous, Fibro-myxomatous or Mucous Polypus. × 300 . 496
118. A Fibrous Polypus removed by the Author from a Boy aged fourteen years, showing Appearance of Growth before and after Removal 499
119. Wilde's Polypus Snare 503
120. Barker's Aural Curettes 505
121. A Sequestrum from the Mastoid Process, with a Portion of the Groove for the Sigmoid Sinus. It was removed by the Author from a Child aged five years, who had suffered from Chronic Otorrhœa following Scarlet Fever . . . 537
122. Diagram showing the Line of the Incision for making the Flap 550
123. Diagram of Adult Skull (natural size), showing the various Points for Trephining. Article by H. P. Dean, Treves' *System of Surgery*, vol. ii. 574
124. Sketch of an Adult Skull to represent an Operation for Treating the Chief Intracranial Complications of Chronic Otitis Media (one-half natural size). Article by H. P. Dean, Treves' *System of Surgery*, vol. ii. 576
125. Section across the Basal Turn of the Human Cochlea. × 100. (Retzius, from Quain's *Anatomy*) 654
126. Section through the Organ of Corti of the Middle Turn of the Human Cochlea, highly Magnified. (Retzius, from Quain's *Anatomy*) 657
127. The Author's Aural Electrode 758
128. The Author's Pharyngeal Electrode 758

METRIC MEASUREMENTS COMPARED WITH THE ENGLISH INCH.

THE subdivisions of the metre having been used in this book, as well as the fractions of an inch, the Author has thought it convenient to place the two scales in comparison.



A millimetre is the $\frac{1}{1000}$th part of a metre.

A centimetre is the $\frac{1}{100}$th part of a metre.

A METRE = 1 YARD $3\frac{3}{8}$ INCHES (or, more exactly, $39\frac{37}{100}$ inches).

A CENTIMETRE = rather more than $\frac{3}{8}$THS OF AN INCH (or, more exactly, $\frac{39}{100}$ths of an inch).*

$2\frac{1}{2}$ CENTIMETRES = not quite 1 INCH (or not quite $\frac{39}{40}$ths of an inch.†

---

* The precise fraction is $\frac{3937}{10000}$.

† The precise fraction is $\frac{3937}{4000}$.

A TREATISE

ON THE

DISEASES OF THE EAR.

CHAPTER I.

INTRODUCTION—GENERAL SKETCH OF THE ORGAN OF HEARING.

Organ of Hearing in the Lower Animals — The Sound-perceiving Apparatus—The Labyrinth and its Divisions—The Sound-conducting Apparatus—The Tympanum and its Contents, the Membrana Tympani and External Meatus.

THE ANATOMY AND PHYSIOLOGY OF THE SOUND-CONDUCTING APPARATUS.

Anatomy of External Ear—Auricle and Meatus—Description of Auricle: its Structure; the Integument Covering it—Muscles of Auricle—Vessels and Nerves of Auricle—Functions of Auricle—Questions as to its Uses in the Reception and Transmission of Sounds—Value of the Auricle as a Resonator—Mr. Gardiner Brown's Views—Function of Intrinsic and Extrinsic Muscles—The Auditory Canal or External Meatus—Cartilaginous and Osseous Parts—Direction and Capacity — Measurements — Relations to Neighbouring Parts — Portions of Temporal Bone corresponding with various Parts of the Ear—Integument of the Meatus; Differences in various Parts—The Ceruminous Glands, Schwalbe's view as to their Functions—Vessels and Nerves of Meatus—The Meatus in Infants—Functions of Meatus—The Ceruminous Secretion.

INTRODUCTION—GENERAL SKETCH OF THE ORGAN OF HEARING.

THE sense of hearing enables the mind to take cognizance of those oscillations of elastic bodies which cause the phenomena of sound. Such oscillations are transmitted to the ear through an elastic medium, and most frequently through the atmosphere; but they may also be communicated by liquids, and with even greater velocity by solid conductors possessing a high degree of elasticity, and directly connecting the source of the sound with the organ of hearing.

In its simplest condition, as in *medusæ*, the organ of hearing takes the form of minute capsules, containing a transparent jelly, and situated at the bases of the marginal tentacles, around the margin of the umbrella-like expansion. In *worms* and *molluscs*, the auditory organ is similarly represented by a closed membranous sac or vesicle, filled with fluid, in which one or more otoliths are found. The vesicle is lined with cells, which, in the higher groups, are connected at their bases with branches of the auditory nerve, and are furnished with bristles at their free extremities. These bristles are the terminal organs of the nerve; in some of the *annulosa* they have been seen to vibrate when sound was conducted into the water in which the creatures were placed. This vesicular membranous structure, with various modifications and additions, is found in all classes of animals, and constitutes the essential part of the organ of hearing, viz., the *sound-perceiving* apparatus. In the human subject it is represented by a more complex arrangement—the *membranous labyrinth*, contained in a small cavity excavated in the petrous portion of the temporal bone (see Fig. 1). This cavity, or osseous labyrinth, is incompletely divided into three parts, the *vestibule* (V), the *semi-circular canals* (H), and the *cochlea;* and similar terms are applied to the corresponding divisions of the membranous labyrinth, which are separated from their osseous case by the periosteum of the latter, and a clear fluid, termed the *perilymph*. On the outer side of the labyrinth is another cavity, the *tympanum* (P), in the anterior portion of which is the opening of the Eustachian tube (TE), communicating with the throat and providing for the access of air to the cavity. The tympanum is bounded externally by a membrane (T) resembling a drumhead, and connected with the internal wall by means of a chain of three small bones. The outer bone of the chain (K) is closely attached to the membrana tympani, while the inner one (S) is applied to an opening in the outer wall of the vestibule. The ossicles are articulated together by joints admitting of certain movements under the action of small muscles, which thus alter the tension of the membrana tympani and the pressure of the lymph of the labyrinth. The ossicles serve to communicate vibrations from the former to the latter of these structures. On the outer side of the tympanic membrane is a canal (AG), the *external meatus*, with an expanded portion for collecting vibrations and conducting them to the internal parts.

For purposes of description the organ of hearing is divided into three portions, termed respectively the *external*, *middle*, and *internal ear*, these being separated from each other in the manner above described. From a physiological point of view, the organ may be regarded as consisting of a *sound-conducting* and a *sound-perceiving* apparatus; the former including the external and middle ear; and the latter,* the structures of the internal ear, the auditory nerve, and the psycho-acoustic cerebral centre.

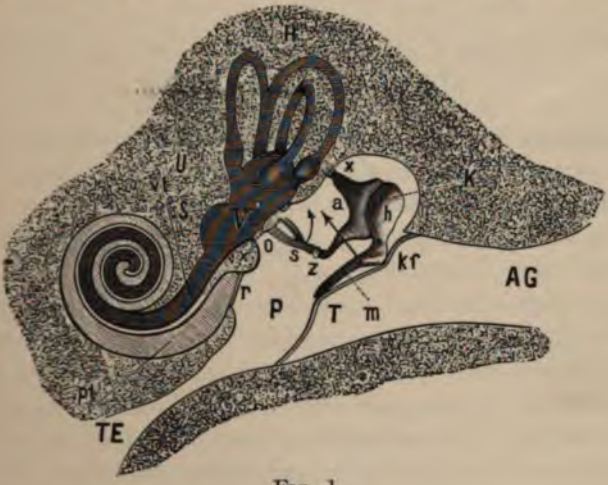


FIG. 1.

SCHEME OF THE ORGAN OF HEARING.

AG, external auditory meatus; T, tympanic membrane; K, malleus with its head (*h*), short process (*kf*), and handle (*m*); *a*, incus with its short process (*x*) and long process—the latter is united to the stapes (*s*) by means of the Sylvian ossicle (*z*); P, middle ear; *o*, fenestra ovalis; *r*, fenestra rotunda; *x*, beginning of the lamina spiralis of the cochlea; *pt*, its scala tympani, and *vt*, its scala vestibuli; V, vestibule; S, saccule; U, utricle; H, semi-circular canals; TE, Eustachian tube. The long arrow indicates the line of action of the tensor tympani; the short curved one that of the stapedius. (*Landois and Stirling.*)

---

* Mr. A. H. Cheatle (*Archives of Otology*, vol. xxvi., 1897, page 185) points out that the *conducting* portion of the auditory apparatus does not end at the base of the stapes; but that the perilymph, the membranous labyrinth itself, and the endolymph ought to be included in that division. Obviously these latter do not belong to the perceptive portion, which is limited to the brain and the auditory nerve with its terminals, at which the conducting portion really ends He thinks that if this true physiological division were kept in mind, "much light might be thrown on the physiology of hearing and on the pathology of ear-diseases." In the chapter on Ménière's Disease further reference will be made to this view.

Before considering the diseases to which these various parts are subject, an account will be given of the anatomy and functions of the sound-conducting apparatus, and this will be followed by a description of the methods of examining the ear.

THE ANATOMY AND PHYSIOLOGY OF THE SOUND-CONDUCTING APPARATUS.

Anatomy of the External Ear.—The external ear consists of two parts: the *pinna* or *auricle*, which projects from the side of the head; and the *auditory canal*, or *external meatus*, directed inwards, and extending to the membrana tympani, which constitutes the external boundary of the middle ear.

The **auricle** is free and expanded, resembling a shell, and forms a kind of funnel around the meatus. Its outer surface, which is directed somewhat forwards, presents several elevations and depressions, some of which are seen in reverse on the free portion of its inner surface. Bounding the greater part of its circumference is a prominent rim, the *helix;* and within this there is another curved prominence, the *antihelix*, which commences below in a projection termed the *antitragus*, and bifurcates above so as to enclose a space, the *triangular fossa*. Within the curve formed by the antihelix, and divided into two portions by the anterior extremity of the helix, is a large, deep, cup-shaped hollow, the *concha*, which opens into the auditory meatus. In front of the concha, and partially covering the meatus, is the eminence termed the *tragus*, while below the concha is a soft and pendulous portion, the *lobule*, or *lobe* of the ear. The margin of the helix sometimes exhibits a few slight projections, the most prominent of which is considered to represent the pointed extremity of the expanded ears of quadrupeds.

The auricle consists mainly of a plate of yellow fibro-cartilage, covered with integument; it is attached by ligamentous fibres to the margin of the external auditory meatus of the temporal bone. A deep cleft, filled up by fibrous membrane, separates the principal portion of the cartilage from that of the tragus and antitragus. Other deep clefts exist between the antitragus and the posterior extremity of the helix, and between the commencement of the latter and the tube of the ear. The cartilage is wanting in the lobule, which is composed of fat and connective tissue. *The integument* covering the auricle presents a few differences on its two aspects. On its inner convex surface it is attached to the cartilage by connective tissue, containing many elastic fibres, and is freely movable, especially at the upper and lower extremities of the ear. On the outer surface the skin is somewhat firmly attached to the cartilage; it is much thinner, and the epidermis is very delicate. On the convex surface many fat cells are to be found in the connective tissue, and these are very abundant in the lobule; they are much more sparsely distributed on the outer surface. Fine hairs with sebaceous glands, and also sweat glands, are scattered over both aspects. The hairs are especially abundant and long about the tragus, the antitragus, and the intertragic notch. In male subjects and in old age they are often very prominent and stiff, and the sebaceous glands near the meatus are apt to become enlarged and filled with secretion.

Six small **muscles** pass between different parts of the auricle; four being situated on its outer, and two on its inner surface. Besides these, there are three muscles connecting the ear with the side of the head, and termed respectively the *superior*, *anterior*, and *posterior auricularis*, or the *attollens*, *attrahens*, and *retrahens auriculam.* Both sets of muscles are but feebly developed in the human subject; very few persons possess the power of moving the auricle and of altering the size of the angle at its attached portion. In many animals, on the other hand, the auricle moves freely under the influence of the will, and the power of estimating the direction whence sounds are propagated is thus considerably increased.

Vessels and Nerves of the Auricle.—The *arteries* are derived from the external carotid, a branch from which, the *posterior auricular*, is distributed mainly to the inner surface. The outer surface is supplied by the *anterior auricular* from the temporal, and these arteries freely anastomose with each other, sending branches through the cartilage and over its margin. The *occipital artery* also gives a branch to the back of the concha. The *veins* of the auricle join the temporal vein, and their blood thus passes into the external jugular. Some auricular veins open directly into the latter vein; others enter the mastoid emissary vein of the lateral sinus.

The auricle is supplied with *nerves* from several sources, viz., the *fifth pair*, the *facial*, the *pneumogastric*, the *cervical plexus*, and the *sympathetic*. The *auriculo-temporal* of the third division of the fifth supplies the outer surface of the ear; the *posterior auricular* of the facial, after receiving a twig from the auricular branch of the pneumogastric, is distributed to the inner surface, and gives filaments to the retrahent muscle. The *auricular* branch of the vagus is distributed to the integument of the back of the ear. The *great auricular* nerve is derived from the cervical plexus, and supplies the integument covering the mastoid process, the back of the auricle, and the outer surface of the concha and lobule. The *occipital* nerve of this plexus also gives a branch to the back of the upper part of the ear and to the *attollens auriculam* muscle. The *vaso-motor* nerves of the auricle are derived from the upper cervical ganglion, and some nerves of this character appear to accompany the great auricular nerve. Section of the sympathetic in the neck of a rabbit is followed by dilatation of the blood-vessels of the ear and increase of temperature of the part; while opposite results are caused by irritating the peripheral end of the divided nerve. It would seem probable that vaso-dilator fibres are distributed to the auricle. They are said to be derived from the last branch of the cervical plexus, whence they pass into the first thoracic ganglion; irritation of these fibres has been found to cause dilatation of the blood-vessels of the ear. A hyperæmic condition of these vessels on one side is sometimes noticed in cases in which the sympathetic nerve in the thorax is compressed by enlarged glands.

Functions of the Auricle.—In addition to its acoustic functions, the auricle protects the external meatus, at least to some extent, from wind and dust, and it also helps to maintain an equable temperature and a proper degree of moisture within the canal. As a part of the organ of hearing, the auricle receives the sonorous vibrations and conducts them to its attached portion and to the meatus. It has also been considered to act as a sound-condenser, and as a resonator for high notes. It cannot be regarded as an absolutely essential part of the organ of hearing, inasmuch as when it is absent sonorous impressions are conveyed to the auditory nerve through the atmosphere, without serious impairment of hearing-power.

With regard to the *part played by the auricle* there are two questions to be considered. In the first place, it is necessary to determine the extent to which its vibrations are transmitted to the walls of the auditory meatus and the tympanum; and in the second place, the degree in which the auricle reflects the sound-waves which reach its surface, towards the column of air in the external meatus. In former times this reflection was regarded as the sole, or, at all events, the principal function of the auricle; but at the present day, conduction of sound is considered to be its most important office.

Owing to its firmness and elasticity, the expanded auricle is well adapted for the reception and transmission of sound-waves, some of which at the same time it reflects. Irrespective of its elevations and depressions, it forms a somewhat flattened plate, impulses against the surface of which are transmitted over it in every direction. These impulses are most freely conducted when the sonorous waves impinge perpendicularly upon the auricle, and the nearer this direction is approached the more extensive will the vibrations become. But the auricle is not a level surface, and the whole of it can never be acted upon in a perpendicular direction by sonorous undulations proceeding from a given point. The importance of the complicated elevations and depressions on its surface thus becomes manifest; for undulations impinging upon the auricle from any direction must fall advantageously, *i.e.*, perpendicularly or nearly so, upon some of them, and then be propagated without much loss of force. The most favourable position for the transmission of sound is when the ear is so situated that the plane of the largest portion of its surface is directed perpendicularly towards the source of the stimulus.

It is very difficult to estimate the amount of reflection which takes place from the auricle. Boerhaave thought that this structure reflected all sound-waves impinging upon it, in such a manner that they were directed into the external meatus. Very careful experiments made with wax models of the ear have, however, shown that no matter at what angle the sound-waves impinge upon the auricle, only a very few of them can possibly be directed towards the meatus, and that there are but few points on the surface from which a sound-wave can take this direction. It would likewise appear that the double reflection from the concha to the tragus takes place to a very limited extent, and that the value of the auricle as a reflector of waves of sound is quite inconsiderable.

A deep concha is said to be accompanied by increase of hearing-power, and some authors have supposed that the size of the angle which the auricle makes with the surface of the mastoid process influences the capacity for perceiving sounds; an angle of 40° is said to be the most favourable, while hearing-power is considerably diminished when the angle is less than 15°. A general statement of this kind must, however, be incorrect, for there is no one angle which can be suitable for all sound-waves. The angle may, certainly, be of considerable importance with reference to sonorous vibrations arising *in front* of the head; we know by experience that hearing-power for these sounds is increased by bending the auricles forward with the hands, and thus enlarging the angles they form with the bone behind them. Persons whose hearing is defective constantly adopt this manœuvre, and also increase the recipient surface, by applying the palm of the hand to the back of the ear. The improvement in hearing is caused, not so much by increased reflection of the sound-waves, as by the increase in the number of those waves, arising in front of the head, which can impinge perpendicularly upon the recipient surface, and thus cause more active vibrations. The same object is attained by the motion of the ears in those animals which are able to direct the orifices towards the source of the vibrations.

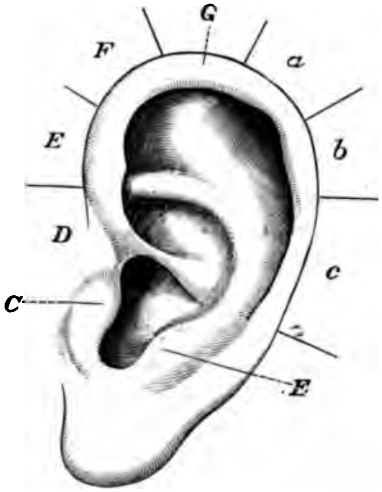


FIG. 2.

THE AURICLE, SHOWING ACOUSTIC POTENTIALS. (*Gardiner Brown.*)

In the act of listening, and whenever we wish to obtain a clear perception of some definite sound, we generally employ only one ear, and endeavour to place it under the most favourable conditions for hearing. We direct the axis of the auditory canal towards the sonorous vibrations, so that as large a portion as possible may enter directly into the canal, and at the same time the auricle, supposing that it forms a medium-sized angle with the head, is placed in a favourable position for the reception of the sound-waves, for many of its parts are perpendicular to them. The value of the auricle as a *resonator* was pointed out a few years ago by the late Mr. Gardiner Brown.* Dr. Zaufal, of Prague, discovered that friction over the tragus produced the middle C in some perfect specimens of auricle, by reason of the vibrations excited in its cartilage. From some experiments made on the auricles of musical persons, Mr. Brown was led to believe, not only that Zaufal's statement was correct, "but also that in a well-formed auricle the whole free margin of the cartilage gives a beautifully graduated ascending scale of notes, forming a complete octave from the tragus in front to the posterior border of the helix behind (C, D, E, F, G, *a*, *b*, *c*)." The antitragus yields a distinct and isolated note, the E, which serves to reinforce the E of the helix. The notes are produced by quickly passing the finger or the rubber-end of a pencil over the different segments between the radial lines indicated in the figure. It will be seen that the notes forming the bases of all music—namely, the first major triad, C, E, G—are produced by friction on the tragus, antitragus, and middle of the upper margin of the helix. The small muscles connected with the ear were believed by Mr. Brown to play a not unimportant part in connection with auditory perception. The *intrinsic* muscles "are serviceable chiefly in increasing the tension, and thus raising the pitch of the resonance of different parts of the cartilage, and regulating the size of its fossæ." The *extrinsic* muscles of the ear assist in the transmission to the tympanum of the vibrations falling upon the auricle, for they serve to render the attachment of the latter to the head more tense during the act of listening, and also keep the tubular part of the cartilage and its membranous connecting link well open, thus increasing the resonance of air in the external meatus.

---

* "The Acoustic Potentials of the Human Auricle." Read before the Otological Section of the International Medical Congress, 1881.

Dr. Burnett, of Philadelphia, so far agrees with Mr. Brown as to quote with approval Helmholtz's view that "the most probable function of the auricle is that of a resonator adapted to augment just those *high* notes or sounds most likely to be of interest and importance to man."

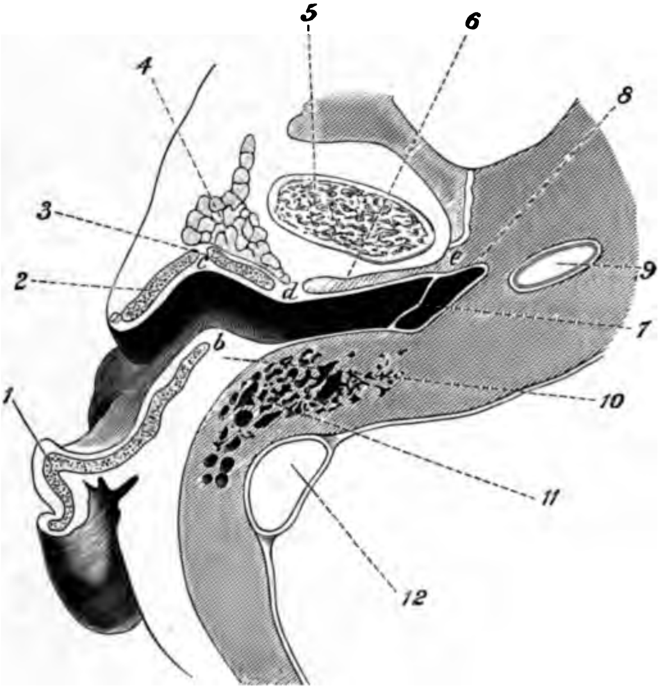


FIG. 3.

HORIZONTAL SECTION THROUGH THE EXTERNAL MEATUS.

Natural size. (*Schwalbe.*)

The surface of the bone marked by lines; that of the cartilage by dots; the external meatus in darker shading; *a b*, external opening of the meatus, the tragus being regarded as a portion of the anterior wall; *b c*, external opening of the meatus, as ordinarily described; *a c* + *c d*, the cartilaginous portion; *d e*, the osseous portion of the external meatus. 1, the cartilage of the concha; *b*, its border projecting forwards; 2, the cartilage of the tragus; 3, medial portion of the anterior wall of the cartilage of the meatus, at *c*, the incisura Santorini major; 4, the parotid gland; 5, condyle of the lower jaw; 6, os tympanicum, anterior wall of the osseous meatus; 7, tympanic membrane; 8, tympanum; 9, internal carotid artery; 10, fibrous portion of the posterior wall of the meatus; 11, mastoid cells; 12, lateral sinus.

The auditory canal, or **external meatus**, passes inwards from the concha to the membrana tympani, and consists of two parts; one being cartilaginous and fibrous, and the other osseous. The former is a prolongation inwards of the cartilages of the concha and tragus. These form a channel open above and behind, and converted into a tube by fibrous membrane extending between the borders of the cartilage. The proportion of the canal made up of fibrous membrane increases from without inwards, while the cartilaginous portion decreases, and finally terminates in a small rounded extremity. Near its commencement it presents anteriorly two or three irregular transverse fissures (the fissures of Santorini), closed by a fibrous membrane which often contains a few muscular fibres. These gaps increase the mobility of the cartilage, and facilitate the straightening of the canal. The length of the external auditory meatus is variously estimated by different anatomists; the differences are mainly attributable to a want of agreement as to the external limits of the canal. Some authorities have included the tragus in their measurements of the walls of the meatus. As pointed out by Mr. Symington, " the only part of the outer end of the meatus which can naturally be distinguished from the concha of the pinna is its posterior wall, for this turns abruptly backwards, while the other walls pass outwards into the pinna without any distinct line of demarcation." Most anatomists now agree with Von Tröltsch in taking as the external boundary of the meatus a sagittal plane passing through the outer end of its posterior wall. He gives 24mm. (or about an inch) as its average length in the adult; the anterior wall being 27mm., lower 26, posterior 22, and upper 21. The cartilaginous portion is about 9mm. in length, its floor being decidedly longer than its superior and posterior walls. It is attached to the osseous portion by means of fibrillary connective tissue, containing many elastic fibres. The osseous portion has nearly double the length of the cartilaginous part; its measurements are thus given by Von Tröltsch—anterior wall, 18; inferior, 16; posterior, 15; superior, 14 millimetres. At its inner end the osseous meatus is terminated by the *membrana tympani*, which is inserted into a narrow groove in the bone. This groove extends around the sides and floor of the opening, but is deficient in front and above; and to the notch thus formed, the grooveless segment of the tympanic ring, the *membrana flaccida*, or Shrapnell's membrane, is attached.

The general *direction* of the auditory canal is from without inwards and slightly forwards; but the cartilaginous portion in passing inwards is directed backwards and upwards, while the osseous portion turns downwards and forwards. The *capacity* of the meatus varies considerably in different individuals. The cartilaginous portion is sometimes so large as to admit the little finger; in other cases it is scarcely larger than a full-sized goose-quill. According to Dr. Burnett, the entire canal is often particularly wide and straight in the negro, so that the *membrana tympani* can be seen without the aid of the speculum. A similar condition is sometimes noticed among Europeans. The canal is oval in form; at the entrance the long diameter is perpendicular, but internally, and at the *membrana tympani*, the canal is widest from side to side. At the line of junction between the cartilaginous and bony portions, the canal is somewhat constricted, and from this point its calibre increases towards both the tympanum and the entrance. At the latter spot it is again diminished. The average measurements in millimetres of the diameter of the canal are as follows:—At the entrance, 5–7; at the widest portion of the cartilaginous part, 9–11; at the junction of the portions, 7–9; and at the membrana tympani,

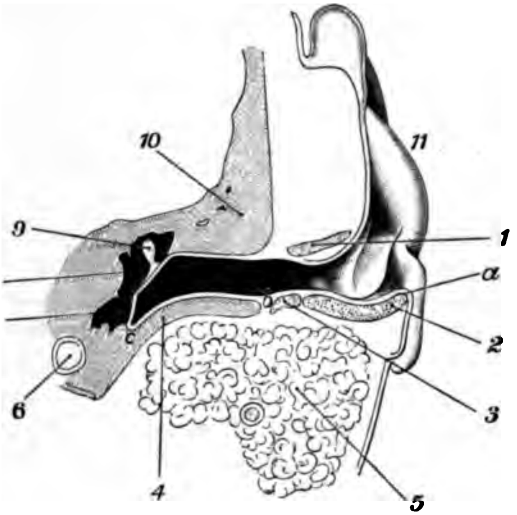


Fig. 4.

Vertical Section through the External Meatus. (*Schwalbe.*)

The surface of the bone marked by lines; that of the cartilage by dots. *a b*, the cartilaginous, and *b c*, the osseous meatus. 1, the cartilage of the tragus, bent down upon the upper wall of the meatus; 2 and 3, portions of the cartilage in the floor of the meatus; between them the incisura Santorini minor; 4, os tympanicum; at *b*, the wedge of connective tissue between the cartilaginous and osseous portions of the meatus; 5, the parotid gland; 6, internal carotid artery; 7, tympanic membrane; 8, the tympanum 9, the malleus; 10, the squamous bone; 11, the concha.

9–11. In some cases, the anterior wall of the osseous canal bulges inwards, so as to prevent the corresponding portion of the membrana tympani from being visible. Occasionally the inferior wall sinks decidedly near the tympanic membrane, so that a sinus or groove is formed (see Fig. 4). It is then very difficult to obtain a distinct view of the lowest part of the membrane; and small foreign bodies, lodged in the sinus, may elude detection.

The *relations* of the external auditory meatus to adjacent parts are of much practical importance. Its *anterior* wall is close to the condyle of the lower jaw-bone, two-thirds of the posterior surface of which correspond to the osseous meatus, while the remaining third is in relation with the cartilaginous portion. As a result of its proximity, the movements of the lower jaw produce alterations in the calibre of the latter part of the meatus. If a finger be passed into the ear, and the mouth opened, the meatus is felt to increase in size, because the condyle of the jaw passes forwards; when the mouth is closed, the canal is lessened in size, because the condyle resumes its place in the glenoid fossa. Fracture of the osseous portion of the anterior wall is sometimes caused by blows on the chin, with hæmorrhage from the ear as a result. External to the condyle, the upper end of the posterior border of the *parotid gland* reaches to the cartilaginous portion of the meatus. When suppuration takes place in the parotid, pus may find its way into the meatus, through one or other of the fissures already mentioned. In like manner, in cases of abscess or ulceration of the external meatus, purulent matter may pass through these fissures into the parotid gland. The *floor* of the external meatus is in relation through nearly its entire extent with the deep process of the parotid gland in the retromaxillary fossa. The *superior wall* of the meatus is represented internally by the attachment of the membrana tympani, and posteriorly it comes into relation with the mastoid cells. More externally, it is separated from the base of the skull, in the middle fossa, by cellular air-spaces communicating with the mastoid cells, the distance between the two parts depending upon the degree in which these spaces and their walls are developed. The *posterior* wall of the meatus is separated by a very thin plate of bone from the mastoid cells, and is about 12mm. distant from the lateral sinus. In this wall is seen the tympano-mastoid fissure, and the mastoid cells are further connected with it by means of small canals containing vessels and strands of connective tissue.

Mention must also be made of other portions of the temporal bone which correspond with various parts of the ear. The *jugular fossa*, for half of its roof, forms the *floor* of the tympanic cavity, the anterior wall of which is a portion of the carotid canal; the *roof* of the tympanum is formed by a *thin plate* of bone on the upper surface of the *petrous portion*, external to the *jugum petrosum*, and near the angle of union with the squamous portion. The *superior border* of the petrous bone is grooved for the *superior petrosal sinus*, which begins at the back part of the cavernous sinus, and receives the blood from the ophthalmic vein, a relationship which may explain the occasional development of ocular and facial symptoms in thrombosis of the sinus from aural disease. The *inferior petrosal sinus* passes backwards along the inferior margin of the petrous bone, and ends in the lateral sinus, or in the internal jugular vein. The former receives the blood from the superior petrosal sinus.

On the posterior surface of the petrous portion is the narrow fissure for the *aquæductus vestibuli.* This is covered by a depressed scale of bone, and is situated about 6mm. behind the internal auditory meatus. Through this aperture purulent secretion sometimes passes into the cranial cavity from the tympanum and vestibule. Another small aperture, for the *aquæductus cochleæ*, begins in a triangular wider depression in the posterior border directly below the internal auditory meatus. This canal passes upwards and outwards through the substance of the petrous bone to the *scala tympani*, and through it a communication takes place between the latter and the subarachnoid space. At the base of the skull, in the plate of bone between the jugular fossa and the carotid canal, is a small foramen through which the *nerve of Jacobson* (from the petrous ganglion of the glosso-pharyngeal) passes to the tympanum, and in the wall of the carotid canal is a small opening for the *tympanic branch* of the carotid plexus. The *auricular* branch of the *vagus* passes in a groove and foramen in the jugular fossa, and close to the canal for the tensor tympani muscle is a foramen for the *small superficial petrosal nerve.* The *large nerve* of that name, from Meckel's ganglion, through the Vidian nerve, passes in a groove on the anterior surface of the petrous portion to a foramen, the *hiatus Fallopii*, and is thus conducted to the aqueduct, where it joins the gangliform enlargement of the facial nerve.

The *integument* of the meatus is continuous with that of the auricle, but gradually becomes thinner and more delicate. It is firmly attached to the wall of the canal, and at the inner extremity it is stretched over the membrana tympani, of which it forms the external layer. It is easily detached from that structure after maceration in water, or when decomposition has occurred; the cuticular lining of the canal can then be drawn out in the form of a tube closed at one end.

The skin of the external meatus exhibits certain peculiarities in different parts. In the cartilaginous portion and on the roof of that part of the osseous meatus which is formed by the squamous bone, it resembles the ordinary integument. But in the remaining larger portion of the osseous meatus, it is very thin (not more than one-tenth of a millimetre in thickness), and closely blended with the periosteum, so as to form a shining fibrous membrane. Neither hairs nor glands are present; but near the membrana tympani there are rows of vascular papillæ, parallel to the long axis of the meatus.

In the cartilaginous portion, and on the part of the osseous meatus formed by the squamous bone, the skin is supported by a thickish and firm layer of connective tissue, containing fat cells, but with papillæ only slightly marked. It contains many fine soft hairs and sebaceous glands, which open into the follicles of the latter. The structures peculiar to this part are, however, the so-called *ceruminous glands*, which are found in great abundance at varying depths from the surface. These glands are a modification of the sweat glands, and are similar to those found in the eyelids. The duct of each gland opens into a pit-like depression, which also contains a minute hair with its sebaceous glands. The walls of these glands consist of a layer of cubical epithelial cells, and an outer layer of longitudinal smooth muscular fibres; the cells are filled with many brownish-yellow granules. Schwalbe[*] states that he has not been able to discover any fat within the ducts or cells of these glands, and he therefore thinks that they do not secrete the fatty constituents of the cerumen of the ear. These, he considers, are formed by the sebaceous glands of the hair follicles, within which fatty masses are easily discoverable. The ceruminous glands are therefore wrongly named; they are really sweat glands modified in a peculiar manner, and in all probability contribute a fluid secretion, containing yellow or brownish granules of colouring matter, which is mixed with the fat yielded by the ordinary sebaceous glands.

---

[*] *Lehrbuch der Anatomie des Ohres*, 1887, S. 437, and *Sinnesorgane*, 1898, S. 178.

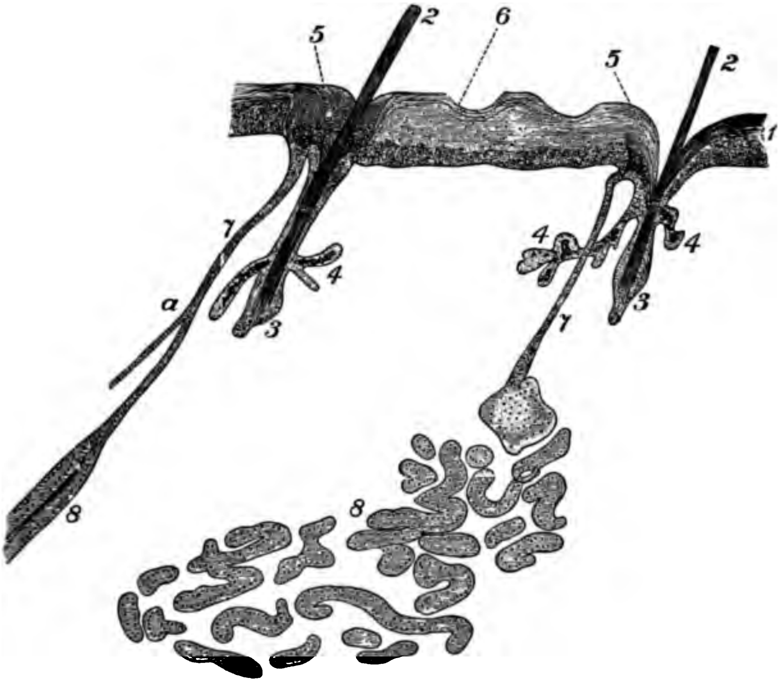


FIG. 5.

SECTION THROUGH THE INTEGUMENT OF THE CARTILAGINOUS PORTION OF THE MEATUS. × 50. (*Schwalbe.*)

1, Epidermis; 2, 2, hairs; 3, 3, hair follicles; 4, 4, sebaceous glands; 5, 5, pit-like depressions, into which the hair-follicles, with their sebaceous glands and the ceruminous glands, open; 6, other small pits divided by the incision; 7, excretory ducts of the ceruminous glands, with a bifurcation at *a*; 8, acini of the ceruminous glands.

The fact that both kinds of glands open into the same cavity explains the mixture of the secretions. The number of these glands has been estimated at from one to two thousand. They decrease in size and number towards the membrana tympani. The mixed secretion is calculated to entangle particles of dust, and to prevent them from passing into the deeper part of the meatus.

In some persons, the cerumen, if not carefully removed from time to time, forms hard masses, more or less blocking up the canal, and interfering with the conduction of sound and the vibrations of the membrana tympani.

Vessels and Nerves.—The largest artery supplying the meatus is derived from the *internal maxillary.* It passes through the anterior wall, and is distributed especially to the upper portion of the canal and also to the tympanum. Other twigs supplying the meatus are derived from the *posterior auricular* and *temporal arteries.* The *veins* take the same course as the arteries, and discharge their blood into the external jugular vein.

The *auricular branch* of the auriculo-temporal *nerve of the fifth* pair penetrates the anterior wall, and is distributed to the canal, which is also supplied by the auricular branches of the *facial* and *vagus* nerves. The branch from the latter comes from the jugular ganglion, and enters the posterior wall of the meatus. It sends one or more twigs to the membrana tympani.

The meatus in the new-born child differs in many respects from the same canal in adults. It forms a relatively narrow cleft, compressed from above downwards. "In the fœtus the meatus is closed, its lower wall being in contact internally with the membrana tympani, and external to it with the superior wall. Towards the end of fœtal life these become separated by an accumulation of epithelium, or vernix caseosa, in the meatus. This is first found at the inner end of the meatus, between the floor and the membrana tympani. . . . At birth, the walls of the meatus are either in contact, or the cavity is filled with vernix caseosa, so that a child is born with its ears practically closed."* Kussmaul states that the most discordant sounds made near a new-born child do not appear to disturb it.

According to Mr. Symington, the meatus in the new-born child is relatively longer than in the adult. In the former the floor measures 20mm., in the latter it is 26mm., or little more than one-fourth longer. After birth, the length of the meatus increases very slowly; the opening up of the canal would seem to be accompanied by some slight diminution in its length. "It is well known that the middle and internal ears are nearly as large at birth as in the adult, and the same would appear to be the case with the external ear, so far as the length of the meatus is concerned." The lumen of the meatus gradually, but very slowly, increases in size after birth; as compared with the length, it is relatively narrow in the infant.

---

* "The External Auditory Meatus in the Child." J. Symington, *Journal of Anatomy and Physiology*, vol. xix. page 28.

A vertical section of the external auditory meatus of a fœtus in the ninth month shows that the tympanic membrane is placed on the inferior aspect of the cranium, and in a plane which is almost horizontal; attached to it externally, as a second portion of the superior wall, is a part of the squamous bone, situated below the linea temporalis. This area (superficies meatus) is the sole representative of an osseous boundary of the canal in the fœtus and in the infant up to the end of the first year. In the new-born infant, the future osseous portion of the meatus is represented by fibrous tissue, into which ossification extends to form the greater portion of the osseous walls. This membrane, which might be called the *fibrous* or *membranous tympanic plate* (Symington), is thin at birth, but becomes thicker and firmer in a few months. According to Mr. Symington, the meatus, at birth, has an osseous roof and posterior wall; the anterior and inferior walls are fibrous. The innermost part of the osseous meatus is formed by the tympanic bone, the development of which commences by the rapid growth of the anterior and posterior tubercles on the tympanic ring of the new-born child. This ring is imperfect above; the gap, 1-2mm. broad, is closed by the curved lower border of the squamous portion, to which the extremities of the ring are united before birth. The ring itself gradually increases in depth, and forms an osseous tube, the tympanic bone, which becomes united behind with the petromastoid portion, and is separated in front from the squamous part by the Glaserian fissure. On the inner border of the tympanic ring is a furrow, the *sulcus tympaniticus*, to which the membrana tympani is attached. In the process of ossification of the external meatus, an aperture often remains in the lower and anterior wall until the fifth year, and in some cases until adult life. After birth, the plane of the membrana tympani gradually becomes less and less horizontal. In the new-born child it makes an angle of 170° with the superior wall of the meatus; in the adult the angle is about 140°.

Functions of the External Meatus.—The auditory canal conducts the sonorous vibrations to the tympanum, and also serves to protect the membrane from mechanical injury, and from sudden changes of temperature. When the external orifice is closed, sounds communicated through the atmosphere become much less distinctly audible; and it is therefore evident that the canal, by virtue of the air that it contains, conducts to the membrana tympani those vibrations which proceed directly from the sounding body, as well as those which are reflected into it by the auricle. But the canal is not a straight tube; it presents several curves, and its diameter varies in different parts, and therefore it is almost impossible that any vibration should impinge upon the *membrana tympani* without first striking the walls of the canal and undergoing reflection. The intensity of the vibrations is thus diminished; but the cartilaginous and osseous walls of the canal aid in the conduction of sound by transmitting the vibrations communicated to the auricle and the bones of the head.

When the meatus is closed, a remarkable change is produced in the perception of those sounds and noises which are conducted mainly or exclusively through the bones of the head to the internal ear. If one meatus be stopped up with the finger, and a vibrating tuning-fork be placed between the teeth, the sound is heard more distinctly on the occluded side than on the other; and if both orifices be closed, the sound is more distinct than when they are open. Similar differences are also observed when sounds are produced in the larynx; in both cases the increased intensity is due to the resonance of the air contained in the meatus. It has indeed been supposed that the difference is only imaginary; but its reality can be demonstrated by another experiment. If a vibrating tuning-fork be held against the upper incisor teeth until the sound is no longer heard, and the meatus be then closed, the perception of the sound returns. There must be a real increase in the intensity of the sound, causing the latter to become once more audible; though the manner in which such resonance is produced cannot be clearly demonstrated. It is possible that the vibrations of the membrana tympani, transmitted to the air in the external meatus, aid in increasing the loudness of the sound. When the canal is open, there is no obstacle to the escape of the sonorous vibrations, and their force is considerably diminished; when it is closed, they will communicate their vibrations partly to the walls of the canal, and partly to the object which closes it. Thus the vibrations would return to their starting-point, the *membrana* *tympani*, and swell the number of the impulses communicated thereto, and necessarily increase the effect produced upon the sound-perceiving apparatus. This explanation is based upon the supposition that sonorous vibrations, transmitted to the organ of hearing through the bones of the head, are communicated by the membrana tympani to the air in the external meatus. Politzer states that the increase in the sensation of sound noticed when the external meatus is closed is due to three causes, viz.: (1) increased resonance of the external meatus; (2) reflection to the *membrana tympani* and *ossicles* of the sonorous vibrations which are communicated by the cranial bones to the air in the external meatus; (3) alterations in the tension of the membrana tympani and ossicles.

The manner in which the experiments, as above described, are utilized in the diagnosis and prognosis of certain aural diseases will be discussed in the chapter on the Examination of Patients.

Under normal conditions the surface of the meatus is coated with cerumen or ear-wax, the mixed secretion of the so-called ceruminous and sebaceous glands. Whether this secretion subserves any acoustic purposes is a doubtful point. The fact that when the secretion is absolutely wanting, hearing power is impaired, and tinnitus is sometimes complained of, has led to the supposition that the cerumen may prevent confused vibrations of the walls of the meatus and the production of that roaring sound which air causes when flowing into a shell.

Removal of the ceruminous secretion is aided by the movements of the jaw, and is often effected by various manual operations. The shape of the cartilaginous portion of the canal, in which the secretion is principally formed, tends to facilitate its extrusion. Dr. Burnett points out that as the wax increases in quantity, it must necessarily "slip into a broader, which is an outer, plane in the external auditory meatus, and thus at last it may be found at the mouth of the auditory canal." When in this position it is more freely exposed to the action of the atmosphere, and, becoming drier, is more easily detached. It is possible that the outward growth of the skin of the external meatus may help to force out the ceruminous secretion. The effects of its undue accumulation and retention will be described in a subsequent chapter.

CHAPTER II.

THE SOUND-CONDUCTING APPARATUS (*continued*).

THE MIDDLE EAR OR TYMPANUM.

Position, Contents, and Boundaries of Tympanum—Membrana Tympani, its Size, Direction, Colour, and Structure—External, Middle, and Internal Layers—Shrapnell's Membrane—Vessels and Nerves—Inner Wall of Tympanum—The Posterior Wall—The Anterior Wall—The Roof or Cranial Wall—The Floor or Jugular Wall—Apertures of Communication with other Parts—Dimensions of the Tympanum—The Attic of the Tympanum—Functions of the Membrana Tympani—The Ossicles—Their Ligaments and Articulations—Movements of the Ossicles—Muscles of the Tympanum, the Tensor Tympani, and the Stapedius—Lining Membrane of the Tympanum—The Tympanum in the Fœtus—Vessels and Nerves of the Tympanum—The Eustachian Tube, its Osseous, Cartilaginous, and Membranous Portions—Mucous Membrane—The Pharyngeal Opening—The Eustachian Tube in Children—Muscles, Fasciæ, and Ligaments connected with the Tube—Vessels and Nerves—Functions of the Tympanum and Eustachian Tube—The Mastoid Portion of the Temporal Bone; the Lateral and Sigmoid Sinuses—The Mastoid Antrum, as a Portion of the Tympanum—The Mastoid Cells, Description and Function.

THE MIDDLE EAR OR TYMPANUM.

The Middle Ear, Tympanum or Tympanic Cavity, is a narrow irregular space, filled with air, in the substance of the temporal bone, and interposed between the external meatus and the labyrinth (Fig. 1, page 3). In front it communicates with the pharynx by the Eustachian tube; behind it opens into the mastoid cells, which are also filled with air; while extended across it is a chain of small movable bones, which place its outer boundary, the *membrana tympani*, in communication with the sound-perceiving apparatus. The bones are connected by ligaments and are moved by two minute muscles; and, in addition to these structures, the tympanum contains vessels and nerves, some of the latter being distributed to the contents of the cavity, while others only pass through it. The tympanum is compressed from without inwards, its smallest measurement being in that direction. Its walls are not everywhere clearly defined, but it is possible to distinguish (1) an external or tympanic wall; (2) an internal or labyrinthine; (3) a posterior or mastoid; (4) an anterior or tubal; (5) a roof or cranial wall; and (6) a floor or jugular wall.

The *external* wall is formed by the membrana tympani and a small framework of bone. Above and in front, the osseous margin is interrupted by a small notch, across the mouth of which the membrane is extended. In form the membrana tympani is nearly oval, but it is wider above than below; its shape and size depend upon the form of the osseous framework in which it is set. In its greatest diameter, from above obliquely downwards, it measures nearly one centimetre, or two-fifths of an inch, while its largest transverse measurement is about eight millimetres. Its thickness is estimated at one-tenth of a millimetre. The plane of the membrane is by no means perpendicular to the axis of the meatus, but forms therewith an angle of about 75°, so that the external surface of the membrane looks obliquely downwards

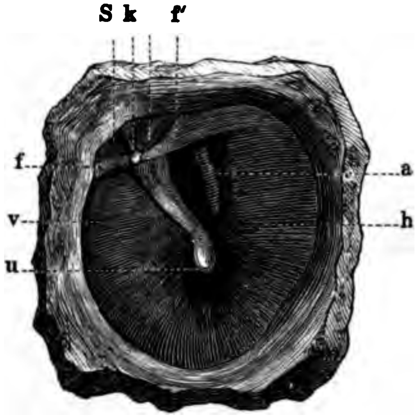


Fig. 6.

Outer Surface of the Left Tympanic Membrane of an Adult, Enlarged.
(*Politzer.*)

v, Segment of tympanic membrane lying in front of handle of malleus; *h*, posterior segment of tympanic membrane; *u*, extremity of handle of malleus; *f*, anterior fold, and *f'*, posterior fold: S, Shrapnell's membrane: *k*, short process of malleus; *a*, long process of incus.

towards the floor of the meatus, and also somewhat forwards. To the inferior wall of the canal, the membrane is inclined at an angle of about 45°, while with the superior wall the angle of inclination is about 140°. These measurements vary, however, in different subjects, on account of the variations in the relative lengths of the osseous walls of the meatus. The longer the anterior and inferior walls, as compared with the posterior and superior, the greater will be the obliquity of the membrane.

The membrana tympani is somewhat concave externally, and presents just below its centre a decided depression, the so-called *umbo*, corresponding with the lower end of the handle of the malleus, which is inserted between its layers. Owing to the traction exerted by this bone, the membrane is drawn inwards and rendered tense. When looked at from the external meatus, the membrane presents the appearance of a shallow funnel, the expanded portion of which bulges out somewhat in front and below. The more transparent the membrane, the less noticeable is the bulging, but in cases of opacity the funnel-shaped depres-

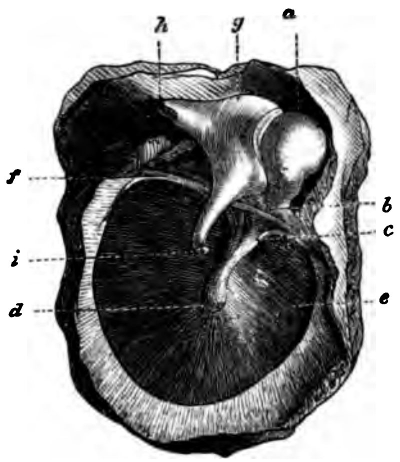


FIG. 7.

INTERNAL SURFACE OF THE LEFT MEMBRANA TYMPANI, ENLARGED. (*Politzer.*)

a, Head of the malleus; *b*, neck of the malleus; *c*, tendon of the tensor tympani and anterior fold of the membrana tympani; *d*, inferior extremity of the handle of the malleus; *e*, anterior portion of the membrana tympani; *f*, posterior fold of the membrana tympani and chorda tympani; *g*, incus; *h*, short process of the incus; *i*, long process of the incus.

sion becomes very manifest. The handle of the malleus is directed from above and in front, downwards and backwards. So far as it extends, it divides the surface of the membrane into two portions, anterior and posterior, the former being the smaller of the two. At the anterior superior part of the membrane, near the osseous margin, is a small projection, caused by the short process of the malleus, which is applied to its internal surface. Extending backwards and forwards, from this projection towards the circumference, are two folds, and within these and starting from the same point are two short *striæ* or lines, which, with a tiny portion of the osseous margin, are the boundaries of Shrapnell's membrane, or the *membrana flaccida*.

The *colour* of the membrana tympani presents several normal variations, due for the most part to the ages of the individuals in whom it is examined. The colour also varies according to the source of the light employed, and the tint of the skin of the meatus. In children, the membrane presents a dull white tint, owing to the thickness of the epidermal layer; in adults, the colour is pearly gray, to which a slight tinge of violet and brownish yellow is sometimes superadded; in old age, it becomes whitish and more or less dull. In the anterior portion of the membrane is a bright triangular spot extending from the umbo downwards and forwards. The apex of this triangle is above and the base below, but the brightness does not extend quite so far as the circumference of the membrane. The peculiar brightness of this spot is probably due to the vertical direction of this portion of the membrane; the rays of light are reflected directly towards the eye of the observer. The appearance presented by the external surface of the membrane will be again referred to in the chapter on the Examination of the Ear.

The membrana tympani consists of three layers—an external, middle, and internal. The *external layer* is derived from the cuticular lining of the canal, and is made up of epidermic cells resting on connective tissue in which the tympanic vessels and nerves ramify. There are no papillæ in this cuticular layer, but behind the handle of the malleus a few glands have been detected. A relatively thick band of connective tissue passes from the upper wall of the meatus over the middle layer of the membrana tympani as far as the umbo, and parallel to the handle of the malleus.

The *middle layer* (lamina propria) of the membrane is strong and fibrous, and is attached through the medium of a still denser, almost ligamentous, portion (*annulus fibrosus*) to the bone, which presents a distinct rim for its reception, except at the upper part. This coat consists of fibrous lamellæ running in different directions; many bands of fibres are seen to converge towards the centre, while others take a circular course. The former commence in the periosteum of the meatus and in the thickened portion at the circumference of the membrane, and pass towards its centre, where they are inserted into the handle of the malleus. There is generally a streak of cartilage forming the actual uniting tissue; and this is especially marked at the extremity of the bone. More internally situated are the circular fibres, which are closely connected with the internal layer, and arise partly from the ligamentous ring and partly from the substance of the membrane. Some are inserted into the handle of the malleus, others into the circumference of the membrane; while another set blend with interlacing fibres. The circular fibres are most abundant near the circumference; towards the centre they become thinner and fewer. The handle of the malleus descends between the radiating and the circular fibres. In addition to the two layers just described, two other sets have been discovered, and named respectively *descending* and *arborescent* fibres. The former are external to the radiating fibres, and pass from the upper segment of the ligamentous ring towards the handle of the malleus. The arborescent or dendritic fibres are most abundant in the posterior part of the membrane; they arise near the periphery, and each divides into several branches which run irregularly and in different directions, passing over a greater or less extent of the membrane.

The *internal layer* of the membrana tympani is formed by the mucous membrane of the tympanic cavity, and consists of pavement epithelium and a thin layer of connective tissue. It is extremely delicate near the centre of the membrane; towards the periphery its surface is studded over with villous projections or papillæ. Further reference will be made to this layer in a subsequent paragraph.

The peripheral portion of the membrana tympani is considerably thickened and strengthened by the so-called *annulus fibrosus*, or ligamentous ring of connective tissue with closely arranged fibres and cartilage-cells. This ring corresponds to a thickening of the periosteum; it is continuous with the periosteal lining of the meatus, and from it many of the fibres of the middle layer take their origin. The membrana tympani is thus connected with the surrounding bone. Mr. R. Lake* has pointed out that the strong periosteum of the anterior upper wall of the bony Eustachian tube is the main source of the fibrous layer of the membrane. Inflammatory processes may thus spread from the former to the latter structure. The fibrous ring is deficient above, and is far more conspicuous on the internal than on the external surface of the membrana tympani.

Above the short process of the malleus there is a small segment of the membrane which differs considerably from the remainder in being looser in texture and less resistant. It is bounded below by two striæ or lines, and above by the margin of a notch in the ring of bone. This so-called *membrana flaccida*, or Shrapnell's membrane, is composed of the outer and inner layers of the membrana tympani, the middle layer being altogether absent, or represented by only a few fibres. The annulus fibrosus is also wanting. The *membrana flaccida* sometimes projects towards the tympanic cavity, and sometimes bulges out towards the superior wall of the meatus. It is stated by some authorities that a small foramen, capable of admitting a bristle, exists in this membrane under normal conditions.

The membrana tympani is supplied with blood from the *vessels* of the external meatus and of the tympanic cavity, and a complete capillary network exists in the fibrous layer. The deep auricular artery, a branch of the internal maxillary, gives off small twigs to the external surface, while those from the tympanic cavity are derived from a branch of the same artery, passing inwards through the Glaserian fissure, and also from a branch of the stylo-mastoid artery. The veins of the outer layer pass into the external jugular; the remainder discharge their blood partly into the plexus surrounding the Eustachian tube, and partly into the lateral sinus. Lymphatic vessels ramify in all the three layers of the membrana tympani; on the internal surface free openings are said to exist in these vessels. Radiating clefts exist between the fibrillary bundles, and represent a system of lymphatic canaliculi. Their walls contain flat cells (tympanic corpuscles), belonging to the category of fixed connective tissue cells or of endothelial cells. The minute structure of the tympanic membrane thus resembles that of the cornea. In addition to the fixed cells, a few leucocytes (or wandering cells) are found in the canaliculi.

---

* *Brit. Med. Journ.*, 1895, vol. ii. page 1292.

The *nerves* are derived mainly from two sources; a branch of the auriculo-temporal of the fifth supplies the external surface; the mucous coat contains filaments from the tympanic plexus, which is formed by Jacobson's nerve from the glosso-pharyngeal, branches from the fifth and the sympathetic nerve.

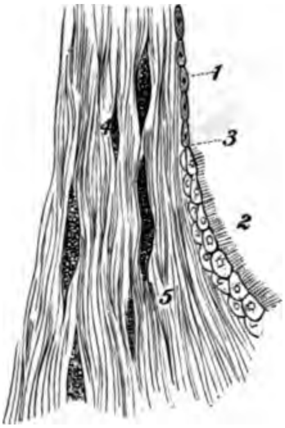


FIG. 8.

SECTION THROUGH A PORTION OF THE LIGAMENTOUS RING OF THE TYMPANIC MEMBRANE, AND OF THE MUCOUS MEMBRANE PROLONGED FROM THE CAVITY. × 350

(*Schwalbe, after Brunner.*)

1. Flattened epithelial cells of the mucous layer of the tympanic membrane; 2, ciliated epithelium of the mucous membrane of the ligamentous ring; 3, spot at which one form of epithelium passes into the other; 4, circular fibres of the ligamentous ring, divided transversely; 5, radiating fibres.

The *inner* or *labyrinthine* wall of the tympanum presents two orifices of communication with the internal ear. Near the upper part is the *fenestra ovalis*, an ovoid opening, about three millimetres long, leading into the vestibule. Against this opening the base of the stapes is applied; while above it is a ridge, which more or less overhangs the fenestra, and indicates the position of the *aqueduct of Fallopius*. This canal, which contains the facial nerve, begins in the upper part of the internal auditory meatus, passes between the cochlea and the vestibule, and, on reaching the inner wall of the tympanum, turns backwards over the fenestra ovalis towards the pyramid in the posterior wall, whence it is directed downwards to the stylo-mastoid foramen. Below the fenestra ovalis is a rounded and prominent elevation named the *promontory* or *tuber cochleæ*, caused by the projection outwards of the first turn of the cochlea. This is marked by grooves or tiny canals which are occupied by filaments of the tympanic plexus. Its most prominent portion is distant about two millimetres from the umbo of the membrana tympani. Below and behind the promontory is the *fenestra rotunda*, situated in a slight depression, and closed by a thin membrane which separates the cavity from the scala tympani of the cochlea. The shape of the opening varies; it is sometimes circular, and sometimes roughly triangular or even oval. In its longest diameter it

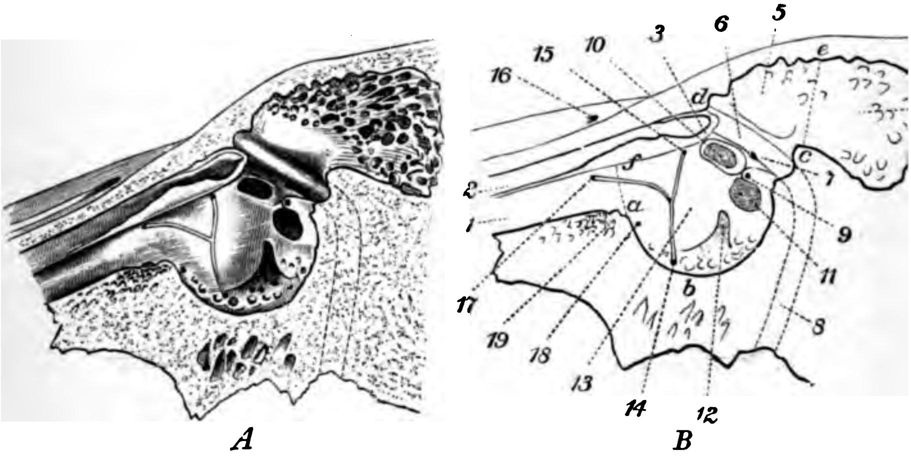


FIG. 9.

A and *B*. THE MEDIAL WALL OF THE LEFT TYMPANUM.
Twice the natural size. (*Schwalbe*.)

a, b, c, d, f, The tympanum proper; *c, d, e,* recessus epitympanicus (aditus ad antrum); 1, the osseous tube; 2, semi-canal for the tensor tympani; 3, the processus cochleariformis; 4, the mastoid antrum; 5, the recessus epitympanicus, with the smooth convexity corresponding with the ampullæ of the external and anterior semicircular canals; 6, prominence caused by canal for facial nerve; 7, aperture in the facial canal; 8, course of the facial canal outside the tympanum, shown by a dotted line; 9, eminentia stapedii, with the opening for the stapedius muscle; 10, pelvis ovalis with the fenestra; 11, sinus tympani; 12, fossula rotunda; 13, the promontory; 14, opening into the tympanum of the lower portion of the canaliculus tympanicus; 15, opening into the tympanum of the upper portion of the same canal; between 14 and 15 the tympanic or Jacobson's groove for the nerve of the same name; 16, the superior or petrous opening of the canaliculus tympanicus; 17, the opening of the canal for the nervus petrosus profundus minor; 18, opening of the carotico-tympanic canal; 19, air-cells near the Eustachian tube.

measures about two and a-half millimetres. At the upper part of the inner wall is a portion of the canal, generally imperfect, for the tensor tympani muscle, the tendon of which bends over the processus cochleariformis, crosses the tympanic cavity, and is inserted into the upper part of the handle of the malleus.

The *posterior wall* of the tympanum presents at its upper part several openings (one of which is usually larger than the others), which lead into the mastoid antrum and cells. Situated at the lower and inner part is a small conical eminence called the *pyramid*, presenting at its summit a minute orifice, through which the tendon of the stapedius muscle passes.

The *anterior wall* of the tympanum presents above the canal for the tensor tympani muscle, and below this, separated by a curved plate of bone, the commencement of the Eustachian tube. A small portion of this boundary is formed by the posterior wall of the carotid canal. The *roof* or *cranial wall* is formed of a plate of bone near the line of union of the petrous with the squamous portion, which, often imperfectly closed, constitutes the external boundary. It varies much in thickness in different subjects. Sometimes only a very thin layer, translucent or even transparent in places, separates the tympanum from the middle fossa of the base of the skull; in other cases there are two compact layers with spongy substance interposed. Small linear chinks, filled in by membrane, not unfrequently exist in the cranial wall; through these, inflammation, arising in the tympanic cavity, may easily spread to the membranes and brain. On the other hand, fracture of this wall, with laceration of the membranes of the brain in contact with it, will allow cerebro-spinal fluid to escape into the tympanum; and abscess of the temporo-sphenoidal lobe has been known to discharge itself, through a carious opening in the subjacent bone, into the same cavity, and thence into the external meatus.

The *floor* or *jugular* wall is narrow and irregular, being in some cases convex and in others concave. These variations depend upon the size and form of the jugular fossa, which is under the floor of the tympanum, and differences similar to those in the roof are sometimes noticed. Thus, in some cases, the two parts are separated only by a thin lamella of bone; in others, there are two layers with spongy tissue intervening.

The tympanic cavity presents many apertures of communication with other parts, and these openings, some of which have already been mentioned, facilitate the extension of pathological processes. The following are the principal communications enumerated by Dr. Macewen*:—

1. The external auditory meatus.

2. The Eustachian tube and canal for the tensor tympani.

3. The mastoid antrum and cells.

4. The petro-squamosal suture, running the whole length of the tegmen tympani, open in early years.

5. The masto-squamosal suture, open in childhood, occasionally remaining unossified in after life, and marked by numerous foramina when ossified.

6. The fenestra ovalis and fenestra rotunda.

7. The Fallopian canal, having communications with the tympanic cavity: in infancy, by a defect in its anterior wall above the fenestra ovalis, and permanently by the aperture for the stapedius muscle and the small nerve-twig for the same; by the channel for the chorda tympani, which again pierces the wall of the tympanum in the fissure of Glaser; by an arterial twig, the stylo-mastoid branch of the posterior auricular, which passes into the tympanum.

The Fallopian aqueduct opens above the cribriform plate into the internal meatus, and through the hiatus Fallopii and a smaller hiatus, in front of this (transmitting the greater and lesser superficial petrosal nerves respectively), into the middle cranial fossa; so inflammation may extend along the perineural sheaths, and set up lepto-meningitis of both posterior and middle fossæ.

8. The foramen between the carotid and the jugular fossa for Jacobson's nerve to the sympathetic plexus and inner wall of the tympanum.

9. The fossa subarcuata—in childhood a wide foramen transmitting a vein to the cells under the superior semicircular canal, and at a still earlier period to the mastoid cells near the outer aspect of the infantile mastoid.

10. The lateral and sigmoid sinus—by means of numerous minute veins through the posterior and lower part of the tegmen tympani and through the mastoid antrum and cells.

---

* *Pyogenic Diseases of the Brain and Spinal Cord*, p. 5.

11. The superior petrosal sinus—by means of numerous minute venous channels.

12. The inferior petrosal sinus—by means of veins from the labyrinth.

13. The temporo-maxillary vein—by many minute veins from the anterior part of the tympanic cavity.

14. Free communication through the bone with the dura matral system of veins.

15. The carotid canal—pierced by several foramina for nutrient vessels and branches of the sympathetic nerves to the tympanum, also by small veins.

16. The jugular fossa—the roof of which is pierced by a great number of veins communicating with the floor of the tympanum and the labyrinth, and also by the foramen for the auricular branch of the vagus, communicating with the Fallopian canal in its course.

17. The tympanic branch of the internal maxillary artery which enters at the fissure of Glaser, to supply the fore part of the tympanum.

The average dimensions of the tympanum as given by Tröltsch are as follows:—

Antero-posterior, from the ostium tympanicum of the Eustachian tube to the mastoid cells ...	13mm.
Vertical (greatest)	15mm.
Vertical at ostium tympanicum...	5-8mm.
Transverse, least distance between membrana tympani and promontory	2mm.
,, at the ostium tympanicum	3-4·5mm.

The Attic.—This term has been applied to the pyramidal space situated above the posterior half of the tympanum, and the most internal portion of the external meatus. It may be regarded as a special portion of the tympanum, marked off therefrom by the axis ligament of the malleo-incudal articulation, and internally, by the prominence of the facial canal. This space has also been named the *recessus epitympanicus;* but it is not a true recess. Some writers describe a third cavity, between the attic and the antrum, and which has been called by Dr. Holmes* "the neck of the antrum"; and by others, the "aditus ad antrum." Unfortunately, this latter term has been applied by Bezold and others to the "attic" proper, and hence some confusion has arisen. According to Dr. Holmes, the *aditus* is bounded above by the tegmen tympani; medially, by the prominence of bone formed by the horizontal semicircular canal, and above this, by cancellated bone; laterally, by the inner edge of the upper back wall of the meatus. The floor of the aditus is formed by cancellated bone. Thus there is the antrum and the attic, and between these two, there is said to be this third cavity, the *aditus ad antrum.*

---

* *Archives of Otology*, 1894, page 35.

The separation, anatomically, of the attic from the tympanum, is justified by the clinical differences between the two parts, and also by the fact that at the end of fœtal life, the attic is outside the tubo-tympanal cavity, which is inclosed on all sides by mucous membrane. Moreover, the attic contains the principal part of the ossicles, besides a number of folds and bands of mucous membrane which are interposed between the tympanum and the antrum, and separate these two parts more or less incompletely.

The attic* has the form of a trilateral prism: one side is directed upwards and outwards; another, directly upwards; and a third, internally. There are thus three longitudinal borders—a superior internal, a superior external, and an inferior. The long axis of the prism coincides with the axis of the Eustachian tube prolonged through the tympanum, but it is slightly curved, with the convexity upwards. According to Bezold, the dimensions of the attic are: transversely, behind the head of the malleus, 5·25-8mm., mean, 6·57mm.; height, apex of short process of incus to the roof, 5-6·25mm., mean, 5·68mm. Anteriorly, the attic is bounded (1) by the tendon of the tensor; (2) by the transverse crest running perpendicularly above the latter and transversely beneath the roof of the tympanum; and (3) by a fold of mucous membrane, varying in form and extent. Posteriorly, the attic passes gradually into the antrum, without any distinct line of separation between the two parts.

The roof of the attic is continuous with that of the tympanum; its internal and larger part belongs to the petrous portion; the smaller and external part to the squamous. The line of separation between these two, the petro-squamous suture, does not, in the adult skull, pass over the middle of the roof; but is somewhat external thereto. A prolongation of the dura mater, containing vessels, and passing through this suture to the attic and tympanum, is of clinical importance, inasmuch as suppuration in the middle ear spaces may be thus propagated to the middle cranial fossa. The pneumatic cells in the roof of the attic are similar to those in the roof of the tympanum. There are, as a rule, many small flat cells; but larger ones occur in the upper and outer angle of the attic, and may extend over the roof of the osseous meatus into the zygoma. When the pneumatic tissue is markedly developed, the air-cells of the roof, after removal of the dura mater, appear as dark spots through the thin layer of compact bone, and minute dehiscences are often noticed. Through these openings, the tympanic mucous membrane comes into direct contact with the dura mater in the middle fossa. In chronic middle ear suppuration, these minute defects in the bone materially assist the extension of morbid processes to the intracranial structures.

---

* This description has been compiled mainly from *Sinnesorgane*, by Schwalbe and Siebenmann, S. 277. (K. von Bardeleben's *Handbuch der Anatomie des Menschen*, 6 Lieferung, 1898.)

The external boundary of the attic is formed by an osseous plate continued from the lateral wall of the antrum, and corresponding with the upper wall of the meatus and the upper half of the posterior wall. This plate is generally very hard and dense, and seldom contains any pneumatic spaces. Shrapnell's membrane is attached to its lower border. Owing to its hardness, the entire upper part of the posterior wall of the meatus is seldom destroyed by carious processes.

The internal wall of the attic is formed of compact bone, belonging to the capsule of the labyrinth. Its surface is convex and prominent, becoming flat towards the fenestra ovalis and towards the antrum. The prominence is due to the projecting portion of the external semicircular canal, and below that, to the facial canal. Beyond the convexity of its inner boundary, externally and posteriorly, the attic communicates by a wide opening with the mastoid antrum. Below, it is connected with the tympanum by an elliptical opening, bounded internally by the ridge of the facial canal, and externally by the tympanal border of the roof of the meatus.

The attic is divided into an inner and an outer half by the malleus and incus. These two divisions, of which the inner is by far the larger, communicate freely above with each other; below, with the tympanum; in front, with the Eustachian tube;

and behind, with the antrum. The outer division is wedge-shaped, broader above and narrowed gradually below, where the body of the incus and the neck of the malleus almost touch the margin of the roof of the meatus. The floor communicates, in front and behind, with the tympanum by a very narrow cleft. The internal division of the attic communicates much more freely with the tympanum; but the passage is encroached upon by the convexity on the inner boundary, by the position of the malleus and incus, by the chorda tympani and by mucous folds and bands.

Functions of the Membrana Tympani.—The acoustic functions of this membrane are easily explained. In common with other tense membranes it is well adapted to receive sonorous vibrations from the atmosphere, and to communicate them to solid bodies with which it is connected. The undulations which pass into the meatus are transmitted to the chain of ossicles, and are thus conducted to another tense membrane, and thence to the perilymph of the labyrinth. There are two places at which the membrana tympani is connected with solid bodies; at its margin it is attached to the osseous walls of the meatus, which are continuous with those of the labyrinth; and, secondly, a portion of its surface is in close union with the handle of the malleus. It is principally to this latter that the membrane communicates its vibrations, though some are doubtless transmitted to the internal ear by the bony walls of the cavity. This transmission is due to the elasticity of the osseous tissue, which is to be regarded as a secondary channel of conduction.

The vibrations of the membrana tympani are of a transverse character—that is to say, they take place in a direction perpendicular to its plane. In consequence of the manner in which the membrane is attached at its circumference, the central part or umbo will make the largest excursions, and the movements of the other portions of the surface will gradually diminish in extent toward the periphery, at which, owing to its firm attachment to the surrounding bone, the vibrations cease. Those movements of the membrane which are produced by the vibrations of the bones of the skull must be longitudinal in character, and in the direction of the radiating fibres; but these have the same effect upon the membrane as the vibrations received from the air. The alternate shortening and lengthening of the radial fibres must produce movements of the umbo perpendicular to the plane of the membrane, or, in other words, transverse vibrations.

The vibrations of the membrana tympani are modified by alterations in its tension; the mechanism by which these changes are effected consists of the tympanic ossicles and their muscles and nerves.

The **ossicles** contained in the tympanum are three in number: the *malleus*, the *incus*, and the *stapes*. By means of the chain formed by these bones, the vibrations of the membrana tympani are communicated to the perilymph of the labyrinth. The ossicles discharge another function—they provide points of attachment for the tympanic muscles, by the action of which alterations are produced in the tension of the membrane and in the pressure of the perilymph.

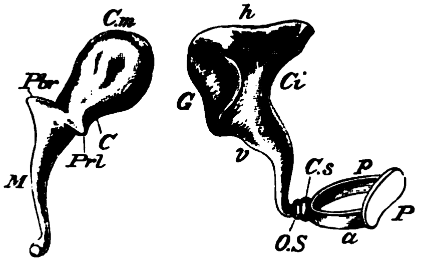


Fig. 10.

The Auditory Ossicles (Right).

C.m, head; *C*, neck: *Pbr*, short process: *Prl*, long process; *M*, handle of the malleus. *Ci*, body; *G*, articular surface; *h*, short, and *v*, long process of the incus. *O.S*, so-called lenticular ossicle; *C.s*, head; *a*, anterior, and *p*, posterior limb; *P*, plate of stapes. (*Landois and Stirling.*)

The *malleus* or hammer (8–9mm. long) presents a large extremity above, termed the *head*, which articulates behind with the incus by means of an irregularly oval surface covered with cartilage. The inferior margin of the articular surface is very prominent, forming a spur which fits into an excavation of the incus. The head is bounded by a constriction or *neck*, from which the *manubrium* or *handle* passes downwards and slightly backwards and inwards between the inner and middle layers of the membrana tympani. The neck and the rounded head of the malleus, which are united to each other at an obtuse angle, extend upwards in the tympanum above the upper border of the membrana tympani, into the *recessus epitympanicus* or attic. The *handle* is about 5mm. long, and is somewhat curved with the concavity in front; sometimes its lower extremity turns sharply forwards. It is firmly attached to the middle layer of the membrana tympani; its periosteal covering and a fibrocartilaginous layer which surrounds the bone, affording points of attachment for the radiating and for some of the circular fibres. The tendon of the tensor tympani muscle is attached to the inner side of the handle, near its upper end.

The *long process* (*processus gracilis, processus Folianus*) passes from the neck forwards and outwards; in early life it extends to the Glaserian fissure, but in adults it is usually represented by a small process of bone connected with the fissure by means of ligamentous tissue. The *short process* is a slight conical projection from the neck; it projects upwards and outwards against the membrana tympani.

The *incus* (anvil) resembles a molar tooth in shape. It consists of a body and two processes—one short and horizontal, and the other longer and vertical in direction. On the anterior and upper part, the body of the bone presents two surfaces covered with cartilage, meeting each other at a right angle, and articulating with the head of the malleus. The short process is directed nearly horizontally backwards towards the posterior wall of the tympanum, with which it is connected by means of ligamentous fibres. The long process descends almost vertically behind the handle of the malleus to a level with the fenestra ovalis; it then bends inwards and somewhat forwards, and terminates in a *lenticular* process tipped with cartilage, which articulates with the head of the stapes. In early life this process constitutes a separate bone.

The *stapes* (stirrup) is articulated with the long process of the incus at an angle which looks upwards, outwards, and forwards. The bone closely resembles a stirrup, and consists of a head, neck, two crura, and a base. The *head* is directed outwards, and sometimes slightly forwards; the surface for articulation with the incus is depressed and covered with cartilage. Below the head is a slightly constricted part, the *neck*, more or less distinct in different specimens; from it the crura diverge. The posterior *crus* is longer and more decidedly curved than the anterior. Each crus is attached to the *base*, a plate of bone which is applied against the fenestra ovalis. The triangular space enclosed by the crura and base is sometimes occupied by a thin membrane. The base is somewhat oval in shape. Its lower border is straight, or slightly concave; the upper margin is curved. The surface which looks towards the vestibule is covered with hyaline cartilage, and is somewhat convex; the outer surface is concave. In the natural state the crura of the stapes are close to the walls of the depression at the bottom of which the fenestra ovalis is situated.

The ossicles are articulated with each other, and are likewise attached at certain spots to the walls of the tympanum. The articular surfaces of the malleus and incus are covered with a thin layer of hyaline cartilage, and kept together by means of a capsular ligament. A fibro-cartilaginous plate, in the form of a meniscus, exists in the joint. The anterior ligament of the malleus is a band of fibrous tissue, which connects the remains of the long process with the Glaserian fissure. This ligament allows the process to rotate slightly inwards on its long axis; and when this rotation takes place, the head of the malleus is moved inwards and the handle outwards. The membrana tympani follows the movements of the handle, its tension being increased when the latter is drawn inwards, and diminished when the movement is in the opposite direction. The movements of the malleus are also regulated by another band of fibres, the posterior ligament, which passes from a crest on the neck of the bone forwards to the wall of the tympanum. These two ligaments form the common axis-band* of the malleus. There is also another band of fibres passing downwards and outwards from the roof of the tympanum to the head of the malleus. This band varies in length, and is altogether absent when the bony surfaces are in contact.

The articular surface of the malleus is elongated and oval in form, and shaped somewhat like a saddle; it is closely adapted to the articular surface of the incus. When the handle of the malleus is drawn inwards towards the tympanic cavity, the head of the bone moves in the opposite direction, and the lower projecting margin which bounds the articulating surface of the incus acts like the tooth of a cog-wheel in limiting the movement.

---

* Helmholtz, *Pflüger's Archiv*, 1868, Bd. I. S. i., and *The Mechanism of the Ossicles*, New Syd. Soc. Trans., p. 119.

The long process of the incus, which is parallel to the handle of the malleus, follows the inward movement of the latter; but when the handle moves outwards, as occurs when the tympanum is distended, the long process of the incus does not move with it, inasmuch as the articulating surfaces are separated from each other. In other words, when the membrana tympani is pressed inwards, the malleus and incus move together, as though they were one bone; but the incus is unaffected when the malleus and the membrane move in the opposite direction, and hence it happens that the stapes is not liable to be detached either from the incus or from the fenestra ovalis.

The manner in which the two bones are connected determines the axis of their rotation. The articulating surface of the incus is fitted to the head of the malleus. The short process of the former bone is almost on the same level as the long process of the latter, and passes above the membrana tympani to be attached to the wall of the cavity. The long process of the incus is parallel to the handle of the malleus, but internal and posterior to it, and its lower extremity forms almost a right angle with the stapes. It is obvious that the movements of these bones must be somewhat complicated. When the malleus and incus move together, their common axis is not the ligament of the malleus, but a line drawn through the long process of the malleus, which is directed forwards, and the short process of the incus, directed backwards. It cuts the malleus just below the neck, and passes obliquely through the body of the incus. The rotation on this axis occurs in a plane which is vertical to that of the membrana tympani, and during rotation the handle of the malleus and the long process of the incus move together in one direction, either inwards or outwards, while the head of the malleus and the upper part of the body of

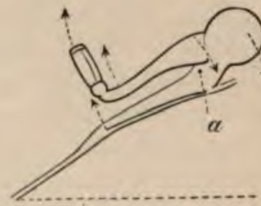


FIG. 11.

(From Wagner's *Lehrbuch der Physiologie.*)

the incus move in the opposite direction. The membrana tympani follows the movements of the handle of the malleus, the external depression becoming more marked when the latter is drawn inwards, and diminishing with the opposite movement. The movement of the stapes must follow that of the long process of the incus; when the latter moves inwards, the base of the stapes presses against the fenestra ovalis, and is slightly withdrawn therefrom when the process moves in the opposite direction. Figure 11 illustrates these movements. It represents a vertical section of the membrana tympani with the ossicles seen from the front—(*a*) shows the position of the axis; the arrows indicate the direction of the movements of the various parts of the lever. The force is applied to the apex of the handle of the malleus; the short process of the incus attached to the wall of the tympanum constitutes the fulcrum; the apex of the incus is the point which acts upon the weight. Helmholtz has found that the entire length of this lever is about 9½mm.; the arm between the two extremities of the incus measures 6⅓mm., or about two-thirds of the whole. (Fig. 12, page 40.) Hence it follows that if the malleus and incus are firmly locked together by the cog-wheel arrangement, the excursion of the tip of the latter must be smaller than that of the corresponding part of the malleus; but the force of the pressure which it transmits to the stapes will be larger by one-half than the force which acts on the tip of the handle of the malleus.

The space through which the bony chain can move is extremely minute. According to Politzer, the greatest excursions take place at the tip of the malleus, and measure seven-tenths of a millimetre. Movement inwards is restrained by the tension of the membrana tympani, and rotation backwards by the anterior ligament of the malleus. But movement is still more powerfully checked by the pressure of the stapes against the margin of the fenestra ovalis, and by the elasticity of the membrane of the fenestra rotunda. If this latter membrane were non-existent, and its place were occupied by an osseous plate continuous with the wall of the tympanum, movement inwards of the base of the stapes would be impossible. When, however, the stapes is forced against the fenestra ovalis, the pressure communicated to the fluid of the labyrinth acts upon the membrane of the fenestra rotunda, causing it to yield as far as its elasticity will permit. Inward pressure of the base of the stapes is likewise resisted by the membrane covering the fenestra ovalis.

From the account thus given of the ossicles and their connections and movements, the mode in which the vibrations of the membrana tympani are conveyed to the labyrinth will be easily understood. The transverse vibrations of the membrane cause the malleus and incus to oscillate around their common axis; the movements of the long process of the latter bone cause corresponding movements of the stapes against the fenestra ovalis.

These vibrations set up wave-movements in the fluid of the labyrinth, the membrane of the fenestra rotunda yielding to the pressure thus applied.

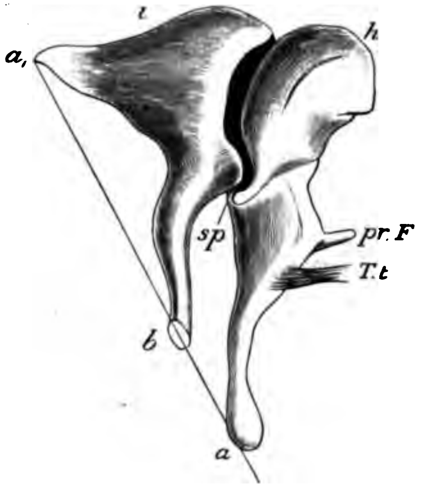


FIG. 12.

THE MALLEUS AND INCUS. (*Helmholtz.*)

The line *a b a* touches from above downwards the apex of the short process of the incus, of the long process, and of the handle of the malleus; *h*, the head of the malleus; *i*, the body of the incus; *sp*, prominent border, bounding head of malleus; *pr.F*, remains of long process of malleus; *T.t*, attachment of tensor tympani muscle.

Muscles of the Tympanum.—The tympanum contains two small muscles, attached to the malleus and stapes respectively, and named the *tensor tympani* and the *stapedius*. The *former* consists of a tapering, fleshy portion, and a slender tendon. The fibres arise from the margin of the anterior opening of the carotid canal, from the cartilaginous end of the Eustachian tube and the adjoining portion of the sphenoid bone, and from the inner concave wall of the bony canal. They are often closely connected by means of tendinous or muscular slips with the origin of the tensor palati muscle. The fibres pass into the canal which is situated above the osseous part of the Eustachian tube, and terminate in a rounded tendon, which bends over the processus cochleariformis nearly at a right angle, and then turns outwards to its insertion into the upper part of the handle of the malleus. The tendon forms a somewhat acute angle with the lower extremity of this portion of the bone, and with the anterior portion of its axis of rotation.

The *stapedius* muscle arises within the eminentia pyramidalis, and in the aquæductus Fallopii, where it lies in front of the facial nerve. At the apex of the pyramid, the fibres unite to form a thin tendon, which passes through an aperture in the bone, and runs forwards in the cavity of the tympanum to its insertion on the posterior border of the neck of the stapes.

When the tensor tympani contracts, the handle of the malleus and the membrana tympani are drawn inwards; the head of the malleus moves outwards, and is closely applied to the incus by means of the cog-wheel arrangement. The base of the stapes is pressed against the fenestra ovalis, and the normal tension of the membrana tympani is increased. It would also seem that contraction of the tensor causes slight rotation of the malleus on an oblique axis passing through its neck. When the muscle relaxes, the elastic force of the rotated axial ligament and of the membrana tympani restores the condition of equilibrium. The motor nerve for this muscle is derived from the otic ganglion, and is supplied by the third division of the fifth. Irritation of the peripheral portion of the latter nerve within the cranium has been observed to cause contraction of the tensor tympani muscle.

It would appear that the contraction of the tensor tympani during hearing is not continuous, but transient. When sound-waves first impinge on the membrana tympani and cause it to vibrate, a sudden contraction of the tensor occurs, but immediately passes off. Deep tones of less than 200 vibrations cause little if any contraction. As to the manner in which the necessary stimulus is communicated to the nerve supplying the muscle, it is probable that the auditory nerve is the channel through which reflex action is excited. The muscle, as a general rule, is not directly under the influence of the will, though in some cases the voluntary action of the muscles of mastication provokes an associated movement of the tensor tympani. Fick* stated that in his own case forcible contraction of those muscles caused a singing tone in the ear, and that a drop of mercury in a capillary tube, fixed air-tight into the external meatus, was rapidly drawn inwards towards the membrana tympani. Helmholtz and Politzer found that suppressed yawning was attended with increased tension of the membrana tympani, and enfeeblement of hearing for certain tones.

The tension of the membrana tympani modifies the perception of sounds in a very important manner. Increased tension lessens the receptive capacity for sonorous vibrations, and conduction to the nerve is thus weakened. A high degree of tension increases the resonance of the membrane for high tones; a low degree has the same effect with regard to deep tones. The function of the tensor tympani is therefore to diminish excessive vibrations, and to regulate the resonance of tones of varying heights. Müller's experiments have proved that a tense membrane on being struck communicates feebler vibrations to the air than one in a more relaxed condition, and it may be assumed that increased tension of the membrana tympani and its bulging inwards diminish the lever-like movement of the ossicles and the intensity of the undulations in the fluid of the labyrinth, and consequently the hearing-power. The latter result can easily be shown to occur by closing the mouth and nose and inspiring forcibly, in which case the air in the tympanum is diminished and the membrane bulges inwards; or by making a forced expiration, when air is driven into the tympanum through the Eustachian tube and the membrane is bulged outwards. In both cases hearing-power is diminished. Politzer has, moreover, shown by direct experiments on the tympanum of a dog recently killed, that the contraction of the tensor tympani influences the conversion of the sonorous vibrations into those of the membrana tympani, and those movements of the incus and stapes upon which the intensity of the effect depends. These results are due firstly to the tension produced in the membrane, and secondly to the manner in which the base of the stapes is pressed against the fenestra ovalis. Moreover, the action of the tensor tympani is not confined to the membrane; when the muscle contracts, the pressure in the labyrinth becomes raised.

---

* *Archiv f. Anat. u. Physiol.*, 1850, p. 526.

The second function of the muscle is the alteration of the resonance of the membrana tympani. Wollaston discovered that impairment of hearing power, due to greatly increased tension of the membrana tympani, was not uniform for all notes, but that low notes were less distinctly perceived, whereas high tones were either unchanged or intensified, as compared with their perception with a medium degree of tension of the membrane. It is well known that tense membranes are easily caused to vibrate, and produce notes by sounds caused in their vicinity, corresponding with their own fundamental tones, or whose number of vibrations is some multiple of their own. Owing to the smallness and tension of the membrana tympani, its fundamental note is extremely high, so that it cannot vibrate in sympathy with the majority of the tones which act upon it. Vibrations are, however, produced by all tones from the highest to the lowest, and in both cases the amplitude of the vibrations is proportional to the intensity of the sound. Moreover, for clearness of sound-perception it is necessary that the membrane should cease to vibrate immediately the sonorous undulations have ceased to act upon it. Such after-vibrations are prevented by the attachment of the membrane to the chain of bones, which offer considerable resistance to its movements. The membrana tympani by itself would, like every other membrane, vibrate actively in sympathy with its own fundamental note or with the octave; but for all others, and especially for lower notes, it would exhibit less decided vibrations. Its capacity of responding to all notes and of diminishing their intensity in an almost equal degree in all cases, is due to its connection with the malleus. This diminution of the extent of the vibrations is no disadvantage; on the contrary, it appears to be a necessary condition for the perception of sounds. The sound-perceiving apparatus is so sensitive that only the feeblest waves are necessary to excite the auditory nerve, and if there were no check upon the vibrations of the membrane, the terminations of the nerve would be liable to suffer. The attachment of the malleus subserves another purpose—it prevents after-vibrations and the continuance of the sensation after the exciting cause has ceased to operate. The malleus acts, therefore, upon the membrane as a *damper*, and checks the movements after the last undulation has acted upon it. The resistance offered by the bone is increased by the weight of its head, by the elastic force of the ligament connecting the long process to the wall of the tympanic cavity, and by the comparatively unyielding character of the stapedio-vestibular articulation.

Various functions have been assigned to the stapedius muscle. It has been regarded by some as co-operating with the tensor tympani, and by others as its opponent. It has also been credited with the power of preventing excessive movements of the stapes in the fenestra ovalis. It cannot assist the tensor, for it contracts at a right angle to the plane of rotation of the incus and malleus. When the muscle shortens, it must tend to draw the head of the stapes backwards, but inasmuch as the base cannot be moved in that direction, its anterior portion is displaced somewhat outwards, while the posterior part is pressed somewhat inwards, towards the fenestra ovalis. In some experiments on dogs, immediately after death, Politzer* found that when the stapedius muscle was caused to contract by irritating the facial nerve, pressure in the labyrinth was reduced, probably as a result of diminished tension of the membrana tympani. This experiment would prove that this muscle is the antagonist of the tensor, for contraction of the latter increases the labyrinthine pressure by increasing the tension of the membrana tympani. In some persons, when the eyelids are forcibly closed, the stapedius executes an associated movement. Dr. Gowers† states that in many individuals a voluntary contraction of the stapedius muscle can apparently be produced. "By closing the eyes tightly, and then trying to turn the eye-balls up, a loud fluttering sensation is produced in the ear, which continues as long as the contraction in the face lasts. It is in part a sound; but in greater part a simple sensation, evidently the result of muscular contraction." Mr. Toynbee regarded the stapedius as aiding the perception of faint sounds; when the muscle acts, the base of the stapes is withdrawn from the fenestra ovalis, and oscillates more freely in response to slight impressions. According to another view, the action of the muscle renders the stapes more firmly fixed, "as the fibrous mass (annular ligament), which surrounds the fenestra ovalis and keeps the stapes in its place, becomes more tense. The activity of the muscle, therefore, prevents too intense shocks, which may be communicated from the incus to the stapes, from being conveyed to the perilymph" (Landois). If this latter theory be correct, the small muscles of the tympanum may be considered as regulating the communication of sonorous undulations to the fluid of the labyrinth, preventing it from being too much affected by loud sounds, in a manner analogous to that in which the iris regulates the admission of light to the eye. Dr. Gowers compares the stapedius with the orbicularis palpebrarum. Both muscles are supplied by the facial nerve, and each is the guardian of an organ of sense. The increased sensibility to sounds noticed in some cases of facial paralysis is attributed to loss of power of the stapedius muscle. Under such circumstances, the stapes is supposed to be less firmly attached to the fenestra ovalis, so that all impulses from the tympanum act more vigorously upon it, and excite more considerable vibrations in the perilymph.

---

* *Beiträge z. Anat. u. Physiol.* Leipzig, 1874, Heft 1, S. xxv.

† The Bradshaw Lecture on Subjective Sensations of Sound, *British Medical Journal*, Nov. 14, 1896, page 1429.

Lining Membrane of the Tympanum.—The walls of the tympanum and the structures it contains are covered by a thin mucous membrane, continuous with that of the pharynx through the Eustachian tube, and prolonged backwards into the mastoid cells. Hence diseases of the pharyngeal mucous membrane may extend not only into the tympanum, but also into the distant cells of the mastoid adjacent to the lateral sinus. Several folds of the membrane traverse the cavity in various directions; one of these, termed the posterior fold, is a continuation of the posterior border of the external ligament of the malleus, and is in close relation with the chorda tympani. This nerve, on entering the tympanum, passes along the free border of the fold for about half its length; it then runs along its posterior surface to the side of the neck of the malleus, and is directed between the tendon of the tensor tympani and a prolongation of the anterior ligament of the malleus to the Glaserian fissure. Where the nerve leaves the free border of the fold, it has the long process of the incus on its inner side, and is attached to it by mucous membrane. Schwalbe states that the posterior part of the nerve is not free, but is usually invested by a special fold of mucous membrane. The anterior fold covers the anterior ligament of the malleus, and is firmer and shorter than the posterior fold. Other folds invest the tendon of the tensor tympani muscle, both processes of the incus, and the tendon of the stapedius. These folds, together with the tympanic membrane and the ossicles, form the boundaries of small *pouches*, the most important of which is situated between the posterior fold and the membrane. This communicates with another pouch, termed Prussak's space, which is situated between the external ligament of the malleus and the short process of that bone. (See Fig. 13.) It is bounded externally by Shrapnell's membrane; internally, by the neck of the malleus; below, by the upper surface of the short process; and above by the external ligament of the malleus. The importance of this pouch or space is due to the fact that isolated accumulations of secretions and of purulent matter are sometimes found in it.

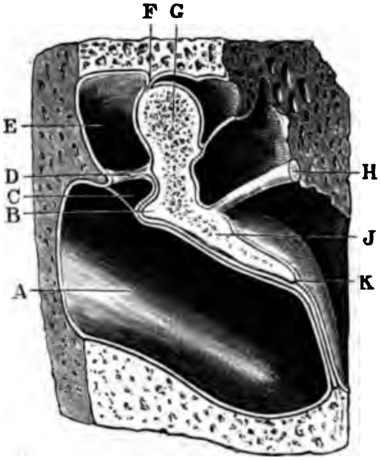


FIG. 13.

SECTION THROUGH THE MALLEUS AND MEMBRANA TYMPANI, SHOWING SOME OF THE POUCHES OR RECESSES OF THE TYMPANIC CAVITY. (*Quain's Anatomy, after Merkel.*)

A, External auditory meatus; B, short process of the malleus; C, inferior external pouch (of Prussak); D, external ligament of malleus; E, superior external pouch: F, superior ligament of malleus; G, head of malleus; H, tendon of tensor tympani; J, handle of the malleus; K, end of handle of malleus.

The mucous membrane is closely connected with the periosteum, and appears as a thin transparent pellicle with a smooth, glistening surface. The periosteal layer is traversed by vessels and nerves, and is thickened for the reception of these structures. The character of the epithelium varies in different parts of the membrane. According to Kölliker, the surface of the ossicles, of the membrana tympani, and of the promontory is covered with tesselated epithelium; but the remaining portions by ciliated cylindrical cells. At the margin of the membrana tympani the latter cells are seen to become smaller, and gradually to lose their cilia. (See Fig. 8, page 27.) The connective tissue, which forms the basis of the membrane, shows a reticular structure in various parts, with meshes containing leucocytes. The periosteal layer is made up of compact strands of connective tissue, running parallel to the osseous surface. Some of the fibrous bundles are raised above the general surface, and contain peculiar structures, formerly regarded as pathological products, but which Politzer has shown to be normal formations. These are generally oval, but sometimes pyriform bodies, having a fibrous structure, the fibres being arranged in layers parallel with the exterior outline. Each of these bodies is traversed from end to end by a fibrous stalk or band, attached at one extremity to the membranous surface below, and at the other to the osseous wall. These structures are purely connective-tissue formations, though they somewhat resemble the Pacinian bodies.

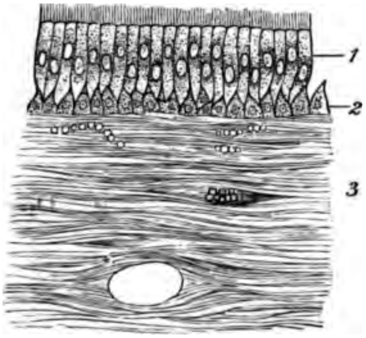


FIG. 14.

SECTION THROUGH THE MUCOUS MEMBRANE OF THE INNER WALL OF THE TYMPANUM OF AN ADULT. × 350. (*Schwalbe, after Brunner.*)

1, ciliated epithelium; 2, basal cells; 3, connective tissue of the mucous membrane.

Anatomists differ in opinion as to whether any glandular structures are contained in the mucous membrane of the tympanum. It was formerly held that these structures were absent, but Tröltsch has described racemose glands near the anterior pouch of the membrane, close to the entrance of the Eustachian tube. Other observers have noticed tubular glands lined with cylindrical epithelium and dilated at their extremities. Luschka and Sappey, on the other hand, state that no glands exist in the normal tympanum, and it may be regarded as certain that even if the contrary opinion be correct, the glands must be few in number and unimportant in character. The walls of the tympanum are moistened by a minute quantity of fluid, which may collect so as to become visible on the floor and in the pouches of the cavity.

The tympanum in the fœtus and in the new-born child presents certain peculiarities which require to be noticed. The cavity can scarcely be said to exist in the fœtus at the fourth or fifth month, for it is completely occupied by a reddish gelatinous material, which is in reality the thickened mucous membrane. According to Tröltsch, the enlargement of the membrane is observable in those portions which cover the labyrinthine wall, the floor, and the ossicles, whereas the mucous layer of the membrana tympani is unaffected. This fœtal condition of the mucous membrane gradually becomes modified ; the soft succulent structure loses its watery intercellular material, and is converted into fibrillary connective tissue. Opinions differ as to the time at which this change takes place, and as to its causes. Some authorities (as mentioned by Schwalbe) state that the change occurs and is completed during the eighth month, so that the tympanum is fully developed in the mature fœtus; others assert that the thickening of the mucous membrane remains till birth, and that its disappearance is the result of respiration. If this latter opinion be correct, the formation of a tympanic cavity is to be regarded as a proof of full and perfect respiration. Schwalbe, however, thinks that the reduction in the thickness of the membrane is the result of developmental processes, and is not dependent upon the access of air to the tympanum.

Vessels and Nerves of the Tympanum.—The *arteries* distributed to the tympanum are derived from the external and internal carotid. The ascending pharyngeal branch of the former gives off small twigs to the Eustachian tube and its muscles, and to the mucous membrane of the anterior and middle portions of the cavity. The anterior part of the cavity is supplied mainly by the tympanic branch of the internal maxillary, which passes through the fissure of Glaser. The stylo-mastoid artery, a branch of the posterior auricular, in its course through the aqueduct of Fallopius, gives off branches which pass through foramina in the posterior wall of the tympanum, and supply the mucous membrane, and that of the mastoid cells, and also the stapedius muscle. These two arteries anastomose freely with each other and form a vascular circle round the margin of the tympanic membrane. Branches of the middle meningeal artery, before it enters the cranium, are furnished to the Eustachian tube, and when the artery reaches that cavity it gives off a small twig, which enters the hiatus Fallopii and anastomoses with branches of the stylomastoid artery. A few twigs from the meningeal artery also pass through the roof of the tympanum. The temporal artery sends small branches through the Glaserian fissure; and lastly, the internal carotid sends a few small twigs through minute orifices in the wall of the carotid canal. The venous blood passes into the middle meningeal vein, the deep auricular, and the veins of the pterygoid plexus. According to Prussak,* the capillaries of the tympanic mucous membrane are peculiar in several respects. The small arteries do not anastomose with each other, and the calibre of their branches, which are given off at acute angles, is very large in proportion to that of the trunk. As a result of this arrangement, the blood-pressure must be considerably diminished, while the velocity of the current is increased, and both these alterations are unfavourable for the escape of exudation into the cavity. Some of the arteries appear to pass into veins without any intervening capillaries.

The *lymphatics* of the tympanum are most abundant in the deeper layers of the periosteum, and the vessels present many rounded dilatations. On the roof of the tympanum, the lymphatics communicate with infundibular or spherical spaces, traversed by a fine network, and often filled with leucocytes, and thus resembling minute lymph-follicles.

The *nerves* distributed to the tympanum are derived from the fifth, seventh, and eighth cranial nerves, and from the sympathetic. The otic ganglion furnishes branches to the Eustachian tube and to the tensor tympani muscle, while the mucous membrane of the cavity is supplied by the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal. This branch arises from the petrous ganglion, and passes to the tympanum through a canal, the opening of which is in the ridge of bone between the jugular fossa and the carotid foramen. On the inner wall of the tympanum the nerve forms a plexus with twigs from the sympathetic. One branch of the tympanic nerve, the small superficial petrosal, passes beneath the canal for the tensor tympani muscle, and thence to the exterior of the skull, through a small opening in the sphenoid bone, to end in the otic ganglion. The tympanic plexus is thus connected with the fifth nerve. Groups of ganglion cells connected with the tympanic nerve have been discovered by Kölliker and Krause. The nerve to the stapedius muscle arises from the facial in the aqueduct of Fallopius, opposite the pyramid, and passes obliquely inwards. The sympathetic nerves are derived from the carotid plexus. They pass through the posterior wall of the canal of that name, and join with the branches of the glosso-pharyngeal and fifth pair to form the tympanic plexus. The nerves contained in the deeper layer of the periosteum are for the most part medullated, but their branches, which form a plexus in the more superficial layer, give off non-medullated filaments. Ganglion cells are connected with the main branches, and are also found immediately beneath the epithelial cells.

---

* *Zur Physiologie und Anatomie des Blutstromes in der Trommelhöhle*, 1868.

Besides the nerves distributed to its structures, the tympanum also contains a portion of the chorda tympani nerve, which leaves the trunk of the facial while within the aqueduct of Fallopius, and crosses the cavity to join the lingual branch of the fifth, with which it passes to the tongue. It enters the posterior part of the tympanic cavity through a canal below the level of the pyramid, where it comes into contact with the posterior fold of the lining membrane (see page 45), and then passes forwards across the membrana tympani to the Glaserian fissure.

The Eustachian tube forms the channel of communication on each side between the pharynx and the tympanum, and consists of two firmly-connected portions, one being cartilaginous and the other osseous. The latter commences in the tympanum; the opening of the cartilaginous portion is in the lateral wall of the naso-pharynx. From end to end the tube measures about 36 millimetres (1·44 inches), one-third of which belongs to the osseous portion. The direction of the tube is not uniform, the two portions being united at an obtuse angle. Looked at from above, the change of direction is scarcely visible; but it is always marked on the under side. The angle coincides with the narrowest part of the tube, and with the place of union of the cartilaginous and osseous portions. The calibre of the latter increases towards the tympanum; the passage through the cartilaginous part takes the form of a vertical slit, the height of which increases gradually towards the pharynx. The general direction of the Eustachian tube is from the tympanum behind and above, forwards, downwards, and towards the mesial line. Its axis forms an angle of 150° with that of the external meatus. The tube is usually said to present an outer and inner wall, a floor, and a roof. The sides, however, almost meet below, and in the cartilaginous portion the upper boundary of the tube is the angle formed by the approximation of the walls.

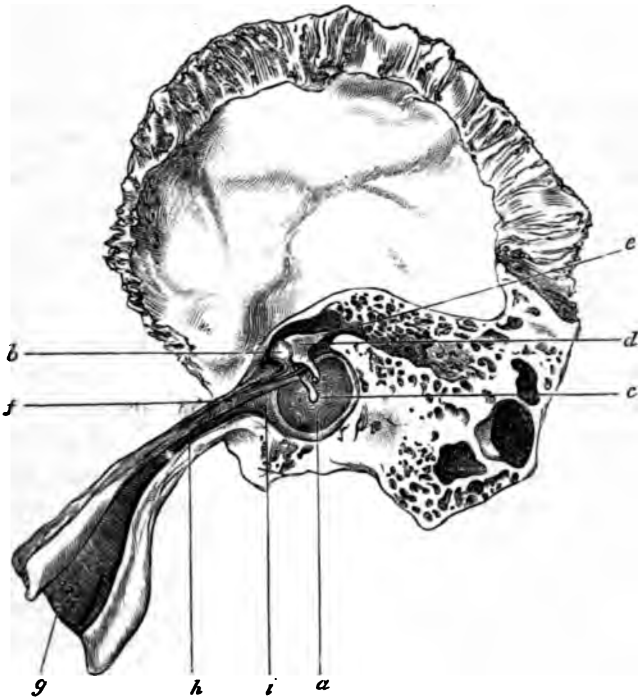


FIG. 15.

EUSTACHIAN TUBE AND TYMPANIC CAVITY, RIGHT EAR. (*Politzer.*)

a, membrana tympani; *b*, head of the malleus; *c*, lower end of the handle of the malleus; *d*, body of the incus; *e*, short process of the incus; *f*, tensor tympani; *g*, ostium pharyngeum tubæ; *h*, isthmus tubæ; *i*, ostium tympanicum tubæ.

The walls of the *osseous portion* of the tube at the tympanic end are continuous with those of the cavity, except below, where the orifice is marked by a sharp curve downwards to the anterior wall of the tympanum. The roof is formed by the floor and lateral wall, partly osseous and partly fibrous, of the canal for the tensor tympani muscle. On transverse section the osseous portion is triangular in form, with the base above and the apex below; towards the tympanum the lateral walls are separated below, and a floor may be said to exist, which is sometimes divided into two parts by a minute crest. The internal wall of the osseous tube is constituted by the neighbouring part of the carotid canal, and close to the tympanic orifice is the opening of the minute canal which transmits the small deep petrosal nerve. Minute perforations sometimes exist in the septum between the osseous tube and the carotid canal. At the tympanic orifice the tube measures from above downwards about 4½mm., and 3½mm. from side to side; at the isthmus the width of the tube is about 1½mm., while from above downwards the average measurement is 3mm.

The mucous membrane of the osseous portion of the tube is closely attached to the periosteum. The epithelium is of the columnar ciliated variety, and is destitute of glands. The membrane is thickest towards the floor of the tube, and contains a vascular network resembling cavernous tissue. Adenoid connective tissue is often found in the mucous membrane beneath the osseous lamella, separating the Eustachian tube from the canal for the tensor tympani muscle.

The cartilaginous portion of the Eustachian tube forms an incomplete wall, the deficiency being supplied by fibrous membrane. When a transverse section is made the cartilage is seen to be bent upon itself, so as to form an angle above, and to constitute about two-thirds of the tube. It is firmly attached by means of fibro-cartilaginous tissue to the indentations of the osseous portion. The cartilage is complete along the inner wall of the tube; its smaller portion forms the upper part of the outer wall. The inner wall increases in height from the isthmus to the pharyngeal opening, where it measures 12mm. At the latter spot the cartilage of the outer wall is much reduced in size, whereas at the isthmus the two portions are nearly equal. At the pharyngeal end the inner wall is much thickened, and its free vertical border, which projects into the side of the pharynx, is often slightly concave, and is prolonged for a short distance at a right angle, so as to assist in forming the floor. The cartilaginous portion, from the isthmus to the pharyngeal opening, measures 24mm., or nearly one inch.

The upper part, or roof of the cartilaginous portion, is firmly attached by means of fibrous tissue to the base of the skull. Commencing at the mouth of the osseous portion of the tube, a distinct furrow can be traced, running inwards and forwards, between the great ala of the sphenoid and the anterior surface of the extremity of the petrous bone. The fibrous tissue occupying the cleft is very closely connected with the roof and inner wall of the Eustachian tube. Further forwards, near the pterygoid process, the inner wall is free and comparatively movable, and projects into the pharynx. The outer wall, on the other hand, at its anterior part, is firmly connected with the bone, and its extremity is attached to a process on the internal pterygoid plate. In its posterior two-thirds, this outer wall of the tube admits of considerable movement as a result of muscular contraction.

The continuity of this portion of the tube is often broken by clefts of various forms and sizes, and filled up with connective tissue and blood-vessels. Sometimes ridges of cartilage project into the canal, and small detached cartilaginous masses are not infrequent in the surrounding fibrous tissue.

Histologically, the cartilage of the Eustachian tube is of the elastic variety; fibres of the latter character are very abundant in the upper and posterior part. The capsules of the cells are distinctly hyaline; they are closely packed together with elastic fibres in the middle portions of the cartilage.

It remains now to describe the *membranous portion* of the tube, or that which completes the gap between the edges of the cartilage. This portion is lined by mucous membrane, continuous with that of the rest of the tube, and supported by a fascia closely connected with the perichondrium, and by the attachments of the tensor palati muscle. This membranous layer is mainly composed of connective tissue, the bundles of which are parallel to the axis of the tube, and the submucous tissue is strengthened by a comparatively thick layer of fat cells. The mucous membrane presents several longitudinal folds, and these are especially marked in the floor of the tube, towards the pharyngeal opening, the closure of which they appear to assist. Two other folds exist in the outer third of the cartilaginous portion; one on the internal and the other on the external wall. These form the floor of a triangle, the apex of which is in the hooked portion of the cartilage. Rüdinger,* who first described this arrangement, was of opinion that this portion of the canal remained permanently open, whereas the lower part, represented by a vertical slit, was always closed, except during the act of swallowing. The upper division he termed the "safety-tube," while the lower constituted the "accessory cleft." The former provides a channel through which air in the tympanum can always pass into the naso-pharynx. Subsequently, Rüdinger was led to believe that in a state of rest the middle portion of the tube was always closed, but that the lower portion stood open, like a funnel, towards the pharynx. Moos states that the pharyngeal opening in a state of rest is always closed by the folds which project upwards from its floor. Other authorities are of opinion that under ordinary circumstances the whole of the cartilaginous portion is closed. Whichever view be correct, it may be assumed that a capillary canal would be filled by the secretions of the tympanum. The greater part of the cartilaginous portion is in all probability closed, except when acted upon by the muscles about to be described.

The tube is lined by ciliated columnar epithelium with basal cells beneath, and goblet cells in varying proportions. The ciliary undulations are said to travel from the tympanum towards the pharynx, but various substances, such as hair, particles of soot, and snuff, are stated to have found their way through the Eustachian tube to the tympanum. Beneath the epithelium is a loose connective tissue layer, with numerous cells, and still more externally the fibres are disposed in a somewhat circular direction. An important constituent of the mucous membrane of the tube is the so-called adenoid, or reticular connective tissue, containing numerous leucocytes, and presenting several modifications and stages of development, sometimes taking the form of a diffuse lymphoid infiltration, and sometimes constituting gland-like structures. Beyond the pharyngeal orifice, this reticular tissue surrounding minute depressions is continued into the pharyngeal tonsil. It is especially developed in children, but in adults it is abundant only in the pharyngeal third of the tube. The excretory ducts of mucous glands open into the bases of the pit-like depressions, as well as between them. These glands are copiously distributed throughout the tube, except at its upper portion.

---

* Schwalbe, *Lehrbuch der Anatomie des Ohres*, S. 535.

The tissues in close contact with the cartilaginous part of the Eustachian tube are as follows: The tensor palati is applied to its lateral and anterior wall, being itself covered by a fascia and the internal pterygoid muscle. The levator palati extends along the floor of the tube, and the posterior and internal wall is at first covered by the origin of this muscle; but in front, it lies under the mucous membrane of the pharynx, and forms the anterior wall of Rosenmüller's fossa. In their further course in the pharyngeal wall, the muscles of the tube are thus placed: The salpingo-pharyngeus, and behind it the ligament of that name, form the innermost layer beneath the mucous membrane. At the anterior border of the muscle, the levator palati takes a direction downwards and forwards, and at the mouth of the tube lies close under the mucous membrane. Upon the outer side of these muscles are the constrictors, and still more forwards, the tensor palati muscle.

The pharyngeal opening of the Eustachian tube is situated in a depression in the lateral wall of the naso-pharynx. Its form varies, being oval, pear-shaped, elliptical, or triangular, with the larger extremity above, and directed somewhat forwards. In other cases it is a mere cleft or slit, while sometimes the opening is kidney-shaped. Its posterior boundary is formed by the pharyngeal end of the cartilage of the tube, the internal wall of which projects like a lip, and separates the opening from the fossa of Rosenmüller. Below, this projection is less marked, and is continuous with the salpingo-pharyngeal fold, and lower down with the posterior pillar of the fauces: it covers the salpingo-pharyngeus muscle. The upper border of the orifice is strengthened by a curved portion of the projecting ridge. In its longest diameter, the opening measures about 6mm., its anterior and upper extremity is about 6cm. from the anterior nasal spine, and 1cm. behind the posterior extremity of the inferior turbinate bone. The opening in adults is somewhat above the lower meatus of the nose, or 1cm. above the level of the hard palate.

During the acts of swallowing and speaking the size and form of the orifice undergo certain changes; these have been observed in cases in which the upper jaw on one side and a portion of the nose had been removed. The opening undergoes no change in ordinary or forced breathing through the nose; slight movements are observable during inspirations of the latter character through the nose and mouth. A considerable change, however, is noticeable during speaking and swallowing. The swelling forming the posterior boundary moves backwards, and the salpingo-pharyngeal fold comes into view; in front of it, as a result of contraction of the levator palati, the floor of the orifice of the tube rises up and separates the walls from each other.

In children, as compared with adults, the Eustachian tube presents certain differences. It is decidedly shorter, but absolutely wider at the isthmus and at the tympanic orifice; the osseous part is longer in proportion to the cartilaginous, and the direction of the canal is almost horizontal. This conformation facilitates the removal of secretion when air is forced through the tube. Less than half the circumference of the tube is formed by cartilage; the pharyngeal orifice is a mere cleft, and the posterior lip is decidedly less prominent. During fœtal life, the opening of the tube is below the level of the hard palate; at birth, it reaches that level; in a child four years old, it is about 3mm. above it.

Several *muscles*, *fasciæ*, and *ligaments* are connected with the cartilaginous and membranous part of the Eustachian tube, and are mainly concerned in rendering its orifice more or less patent. There are at least three muscles, of which the first in importance is the *tensor palati*, or as it is sometimes called, the *dilator tubæ*. It arises from the root of the internal pterygoid plate of the sphenoid bone, from the external cartilaginous portion of the tube, and from the membranous portion. Its outer surface gradually becomes tendinous, and a portion of it is closely united with the aponeurosis of the internal pterygoid muscle in the pterygoid fossa. The muscle then turns round the hamular process, being here represented by a somewhat broad tendon, which passes into the aponeurosis of the soft palate, and is also attached in front to the posterior border of the hard palate.

When the *tensor palati* contracts, it separates the hooked portion of the cartilage and the membranous part from the internal plate, and thus dilates the tube. Certain fibres which are attached to the lateral cartilage and to the notch at the base of the pterygoid plates are especially active in this direction. There is also a layer of fibrous tissue, connected on the one hand with the membranous portion of the tube, and on the other with the aponeurotic expansion of the tendon of the muscle, and this tissue is tightened when the muscle contracts and draws the membranous from the cartilaginous portion of the tube. The tensor palati is often closely connected with the tensor tympani muscle.

The act of swallowing invariably causes the Eustachian tube to open, but the latter result can be independently effected by some persons. The tensor palati muscle is supplied by the motor portion of the fifth nerve.

The *levator palati* arises from the under surface of the apex of the petrous bone, just anterior to the inferior opening of the carotid canal, from the commencement of the external plate of the cartilage of the tube, and from the contiguous portion of the floor as far as the posterior extremity of the internal plate. In their course forwards the fibres of the muscle are applied to the lower aspect of the tube, being nearly parallel to its axis. Near the pharyngeal opening the muscle passes under the membranous base of the tube downwards towards the soft palate, and divides into two portions. The smaller of these is continued forwards towards the posterior nares, and is inserted into the posterior nasal spine and the periosteum of the hard palate, while the larger portion passes downwards in the soft palate, and reaches the arch of the palate on the opposite side, the right and left muscles thus crossing each other. When this muscle contracts, its belly thickens, and forms a projecting cushion on the floor of the tube.

The principal function of this muscle is to elevate the soft palate, but by raising the floor of the tube at the pharyngeal opening, it so far diminishes the size of the aperture. This result is observed during deglutition, the act of speaking, and deep inspiration. The *levator palati* is not to be regarded as the antagonist of the tensor, for it comes into action during the first part of the act of deglutition, whereas the contraction of the tensor takes place at a later stage and causes the pharyngeal opening of the tube to enlarge. Moreover, the swelling caused by the contraction of the levator separates the walls of the tube to some extent, and alters the shape of the aperture, and this action lessens or altogether neutralizes the diminution caused by the swelling in the floor. It is therefore more correct to say that the action of the muscle is to modify the shape of the aperture, and to assist the effect of the contraction of the tensor palati by slightly separating the walls of the tube and by fixing the base.

The third muscle connected with the Eustachian tube is the *salpingo-pharyngeus*, or the *retractor tubæ*. This arises from the thickened pharyngeal end of the inner cartilaginous plate, and passes backwards to the muscles of the pharynx into the connective tissue between the latter and the mucous membrane. It is sometimes absent, and is seldom very conspicuous. When it contracts it draws the pharyngeal extremity of the inner cartilaginous plate in a direction backwards and downwards, and assists to open the mouth of the tube during the act of swallowing.

Several so-called *fasciæ* are described in connection with the Eustachian tube. (1) There is a layer of connective tissue between the tensor and levator palati muscles; it is attached to the membranous portion of the tube, and passes outwards and downwards. This *fascia salpingo-pharyngea* is attached to the hamular process, and to the lateral wall of the pharynx. Some fibres of the tensor palati arise from this fascia, and when they contract they draw the membranous portion of the tube downwards and outwards. (2) Another fascia, which is connected with the internal pterygoid muscle, covers the lateral cartilage and the membranous tube, together with the tensor palati. When the internal pterygoid contracts, this fascia, the portion of the tube connected with it, and the tensor palati are put upon the stretch, so that the first-named muscle forms part of the motor apparatus of the tube. (3) The *salpingo-pharyngeal* ligament arises from the posterior surface of the inner cartilaginous plate, and passes backwards to the constrictors of the pharynx. When the superior and middle constrictors act, the internal cartilaginous plate is forcibly retracted, and this ligament, which often contains portions of cartilage, may therefore be described as the *retrahens tubæ*.

Vessels of the Eustachian Tube.—The tube is supplied by the ascending pharyngeal artery, a branch of the middle meningeal, and by small twigs direct from the latter artery and from the internal carotid before it enters the canal and while passing through it. The veins are numerous, and some of them have important relations. Those which form the internal pterygoid plexus pass along the external cartilaginous plate to the base of the skull, and some of them open into the cavernous sinus. These veins are freely connected with the plexus around the glenoid fossa and the anterior wall of the meatus, and open either into the facial or internal jugular vein. When this plexus is congested, the cartilaginous plates are brought nearer to each other, and the calibre of the tube is diminished.

The *nerves* of the Eustachian tube are supplied mainly by the fifth pair; the tensor palati receives a branch from the otic ganglion, presumably from the motor portion of the fifth, and the pharyngeal opening of the tube receives twigs from the superior pharyngeal nerve. When the fifth nerve is irritated, the tensor palati contracts and the mouth of the tube is enlarged anteriorly. The levator palati is supplied from the pharyngeal plexus with nerves that reach the latter, "from the bulbar portion of the spinal accessory nerve through the vagus and glosso-pharyngeal trunks."* The osseous portion of the tube receives twigs from the tympanic plexus.

Functions of the Tympanum and the Eustachian Tube.—The membrana tympani and the chain of bones connected with it require space for their vibrations, and this is provided by the cavity of the tympanum. If the latter were not furnished with any channel of communication with the atmosphere, the air it contains would be compressed by the inward movement of the membrane, the vibrations of which would meet with a corresponding resistance. As a second result, the membrane of the fenestra rotunda would be prevented from moving outwards when acted upon by the perilymph; but these consequences are prevented by the escape of air through the Eustachian tube. Moreover, if the cavity were tightly closed, its gaseous contents would be only such air as might escape from the blood-vessels, and this would be subject to frequent variations in composition and tension as compared with the air on the outer side of the membrane. These differences would modify the receptive capacity of the membrane for sonorous undulations and its power of conducting sound. The necessity for a tube connecting the tympanum with the outer air is thus easily demonstrated.

The Eustachian tube does not serve to conduct sonorous undulations from the pharynx to the tympanum, neither is it a channel for the passage of sounds produced in the throat. Under ordinary circumstances a man's own voice is not more distinctly heard than that of another person speaking close to him. When

---

* Cleland and Mackay, *Human Anatomy*, p. 349.

The third muscle connected with the Eustachian tube is the *salpingo-pharyngeus*, or the *retractor tubæ*. This arises from the thickened pharyngeal end of the inner cartilaginous plate, and passes backwards to the muscles of the pharynx into the connective tissue between the latter and the mucous membrane. It is sometimes absent, and is seldom very conspicuous. When it contracts it draws the pharyngeal extremity of the inner cartilaginous plate in a direction backwards and downwards, and assists to open the mouth of the tube during the act of swallowing.

Several so-called *fasciæ* are described in connection with the Eustachian tube. (1) There is a layer of connective tissue between the tensor and levator palati muscles; it is attached to the membranous portion of the tube, and passes outwards and downwards. This *fascia salpingo-pharyngea* is attached to the hamular process, and to the lateral wall of the pharynx. Some fibres of the tensor palati arise from this fascia, and when they contract they draw the membranous portion of the tube downwards and outwards. (2) Another fascia, which is connected with the internal pterygoid muscle, covers the lateral cartilage and the membranous tube, together with the tensor palati. When the internal pterygoid contracts, this fascia, the portion of the tube connected with it, and the tensor palati are put upon the stretch, so that the first-named muscle forms part of the motor apparatus of the tube. (3) The *salpingo-pharyngeal* ligament arises from the posterior surface of the inner cartilaginous plate, and passes backwards to the constrictors of the pharynx. When the superior and middle constrictors act, the internal cartilaginous plate is forcibly retracted, and this ligament, which often contains portions of cartilage, may therefore be described as the *retrahens tubæ*.

Vessels of the Eustachian Tube.—The tube is supplied by the ascending pharyngeal artery, a branch of the middle meningeal, and by small twigs direct from the latter artery and from the internal carotid before it enters the canal and while passing through it. The veins are numerous, and some of them have important relations. Those which form the internal pterygoid plexus pass along the external cartilaginous plate to the base of the skull, and some of them open into the cavernous sinus. These veins are freely connected with the plexus around the glenoid fossa and the anterior wall of the meatus, and open either into the facial or internal jugular vein. When this plexus is congested, the cartilaginous plates are brought nearer to each other, and the calibre of the tube is diminished.

The *nerves* of the Eustachian tube are supplied mainly by the fifth pair; the tensor palati receives a branch from the otic ganglion, presumably from the motor portion of the fifth, and the pharyngeal opening of the tube receives twigs from the superior pharyngeal nerve. When the fifth nerve is irritated, the tensor palati contracts and the mouth of the tube is enlarged anteriorly. The levator palati is supplied from the pharyngeal plexus with nerves that reach the latter, "from the bulbar portion of the spinal accessory nerve through the vagus and glosso-pharyngeal trunks."* The osseous portion of the tube receives twigs from the tympanic plexus.

Functions of the Tympanum and the Eustachian Tube.—The membrana tympani and the chain of bones connected with it require space for their vibrations, and this is provided by the cavity of the tympanum. If the latter were not furnished with any channel of communication with the atmosphere, the air it contains would be compressed by the inward movement of the membrane, the vibrations of which would meet with a corresponding resistance. As a second result, the membrane of the fenestra rotunda would be prevented from moving outwards when acted upon by the perilymph; but these consequences are prevented by the escape of air through the Eustachian tube. Moreover, if the cavity were tightly closed, its gaseous contents would be only such air as might escape from the blood-vessels, and this would be subject to frequent variations in composition and tension as compared with the air on the outer side of the membrane. These differences would modify the receptive capacity of the membrane for sonorous undulations and its power of conducting sound. The necessity for a tube connecting the tympanum with the outer air is thus easily demonstrated.

The Eustachian tube does not serve to conduct sonorous undulations from the pharynx to the tympanum, neither is it a channel for the passage of sounds produced in the throat. Under ordinary circumstances a man's own voice is not more distinctly heard than that of another person speaking close to him. When sounds are uttered with both nose and mouth closed and the orifices of the Eustachian tubes open, they are heard with exaggerated intensity, and they appear to originate within the tympanum itself, this difference being due to the fact that the tubes are open. Under ordinary conditions their walls are in apposition; the expiratory current and therefore the sonorous vibrations produced by the vocal cords do not pass into the tubes, for the air does not impinge upon the openings in a favourable direction, and can easily escape through the mouth and nares. The mechanism of the Eustachian tube presents no obstacle to the passage of air from the tympanum, but its valve-like closure obstructs the passage in the opposite direction, and the tube is opened either by muscular action, as in swallowing, or as a result of increased pressure of air, as in Valsalva's experiment. When the tube is open, the intensity of sounds produced in the larynx is due to the same cause as the alteration which is noticed when words are spoken through a tube into the ear. Besides this, when sound is conducted through the Eustachian tube, the vibrations of the membrana tympani are strengthened by resonance from the walls of the cavity. Some of the vibrations reflected from the internal surface of the membrane are thrown back upon it from the sides of the tympanum, and thus strengthen the sound.

---

* Cleland and Mackay, *Human Anatomy*, p. 349.

During swallowing, the Eustachian tube opens, and allows air to escape from the tympanum. At the beginning of the act, however, the movement upwards of the soft palate tends to close the opening. In the second stage of swallowing, the pharynx descends, the tensor palati contracts, and the orifice is rendered patent. Gellé, however, gives a somewhat different account of the phenomena which occur in the Eustachian tube during the act of swallowing. According to his* experiments, in that stage of the act during which the pharyngo-nasal cavity is shut off by the horizontal elevation and tension of the soft palate and the action of the superior constrictor, the walls of the tube are separated and the canal is opened. At that moment air is withdrawn from the tympanum, and the membrane becomes concave, or moves inwards. Immediately afterwards air passes in the opposite direction, as a result of the elasticity of the membrane which comes into play when the action of the muscles of deglutition is suspended.

---

* *Suite d'Etudes d'Otologie, De l'Oreille*, p. 119 *et seq.*

Besides that of admitting air to the tympanum, the Eustachian tube has another important function, viz., that of providing for the escape of secretions from that cavity. The movements of the cilia are directed towards the pharynx; but the opening of the tube is near the roof of the tympanum, and therefore unfavourably situated for the removal of secretion, when only moderate in quantity.

A description of the mastoid portion of the temporal bone and the mastoid cells will complete this portion of the subject.

The **Mastoid portion** of the temporal bone is situated behind the meatus; it contains cellular spaces which communicate with the tympanum, and are lined by mucous membrane prolonged from that cavity. Its external surface is convex and rough, and presents several foramina, one of which, much larger than the others, is situated close to the posterior border, and serves for the passage of a vein to the lateral sinus. Behind the aperture of the ear the mastoid portion is prolonged downwards into a nipple-shaped projection—the *mastoid process*, on the inner side of which is a deep groove, the *digastric fossa*, which gives attachment to the posterior belly of the muscle of that name. On the inner boundary of this fossa is a slight groove for the occipital artery. In some specimens, another groove, running from before backwards, divides the mastoid process into two portions.

The outer surface of the mastoid process, and especially of its posterior part, is rough and perforated, and occasionally so incomplete as to allow the cellular structure of the bone to become visible. In extreme cases of this kind some of the air-cells open externally, and thus establish a communication between the tympanum and the subcutaneous tissues of the mastoid portion. Morbid contents of the mastoid cells might thus pass to the side of the neck and occiput, and Gruber * states that he has often seen emphysema of these parts result from injecting air into the tympanum. The masto-squamosal suture sometimes remains unossified, and furnishes another outlet whereby purulent contents of the tympanum may pass to the outside of the cranium. The internal surface of the mastoid process presents a deep sigmoid groove which lodges part of the lateral sinus†: the mastoid foramen opens into this groove.

---

* *Lehrbuch der Ohrenheilkunde*, 2 Aufl. S. 26.

† For purposes of description, the lateral sinus may be divided into two parts.

The mastoid cells, which are not developed till after puberty, communicate with the tympanum by means of one or more openings in the posterior wall of that cavity. At its upper part is a space which is termed the *recessus epitympanicus*, or "attic," and contains the larger portion of the incus and nearly half of the malleus. (See p. 31). This space extends backwards into the *aditus*, and thence into the mastoid *antrum*, the upper wall of which is directly continuous with the roof of the tympanum. The antrum measures from behind forwards about 12mm., and from above downwards about 8mm.; but its size varies considerably in different specimens. Its floor may be said to begin at the spot where the short process of the incus is attached to the posterior wall, with which it forms almost a right angle, and it is continued downwards to the commencement of the mastoid process. It is considerably below the level of the opening by which the antrum communicates with the tympanum, and secretions are therefore liable to accumulate in this passage. The roof of the antrum is external to the ridge of the superior semi-circular canal. Its external wall consists of the vertical plate of the squamous, portion, extending downwards from the temporal ridge. This plate is marked off from the mastoid by the masto-squamosal suture, which is wide in infancy and occasionally persistent through life. It runs from the notch at the junction of the parietal, squamous, and mastoid, obliquely over the mastoid process, behind the tympanic ring, and either quite reaches the stylo-mastoid foramen or stops short of it. The anterior wall, dividing the antrum from the inner part of the external auditory canal, is thin and sometimes defective, and secretion has been known to escape through it from the antrum into the external ear. The inner wall of the antrum is located at a variable distance from the surface of the skull, the variability depending upon the general form and thickness of the cranium and the size of the antrum itself (Macewen). The walls of the antrum present many openings, of various forms and sizes, com-

The first extends from the internal occipital protuberance to a point called the *asterion*—*i.e.*, the spot where the parietal, occipital, and temporal bones meet. To the remainder of the sinus, extending from this point to the jugular foramen, the term "sigmoid" is applied. The knee, or anterior convexity, of the sigmoid, is generally on a level with the upper part of the external osseous meatus. The distance between the latter and the sigmoid groove varies from one or two to thirteen millimetres. When the groove advances in an anterior direction, it also projects nearer to the external surface of the bone. Its breadth varies from a quarter to three-quarters of an inch.

municating with the mastoid cells and with similar cells in the squamous portion of the bone. The mastoid cells may be divided into two sets, one extending horizontally backwards, and the other downwards into the mastoid process.

Mr. A. H. Cheatle* points out that the antrum is a definite part of the middle ear, and should therefore be disassociated from the mastoid process, and described as the tympanic antrum. His reasons for making this alteration are as follows:—The antrum exists at birth, whereas the mastoid process does not begin to make its appearance until the end of the first year, when it becomes developed from the mass of bone below and behind the cavity. At birth the antrum is large enough to hold a small pea, and is lined with the same membrane as that covering the middle ear. In a fœtal temporal bone, at six months, a recess is seen behind the incus, continuous with the inner tympanic wall, smooth, and slightly overhung by the posterior part of the tegmen tympani, which anteriorly forms the roof of the middle ear. This recess is the inner wall of the antrum, and is converted into a cavity by the juxtaposition of the tegmen to the posterior part of the outer plate of the horizontal portion of the squama.

The *number*, *size*, and *contents* of the mastoid cells vary considerably in different specimens. Sometimes the cells contain air, and occupy the whole of the mastoid process, and even extend backwards to the occipital suture, upwards and forwards to the root of the zygomatic process, and inwards for varying distances along the petrous portion. They thus surround the superior and posterior wall of the osseous meatus and a large portion of the labyrinth, and are often found beneath the compact tissue of the wall of the jugular fossa, and of the posterior part of the carotid canal. In another class of cases the air-cells are confined to the base of the mastoid process, the remaining portion being either compact or occupied by reddish or yellowish diploetic tissue containing much fatty matter. In 100 specimens examined by Dr. Zuckerkandl,† many variations were found in the proportion between diploetic and pneumatic mastoid cells. In 40 the cells were altogether pneumatic; in 22, completely diploetic as far as the antrum; in 29, the apex alone was diploetic; and in 9 cases the condition of the lower half was of that character, while the

---

* *Archives of Otology*, vol. xxv. No. 3, 1896.

† *Monatsschrift f. Ohrenheilkunde*, Bd. XIII. 1879.

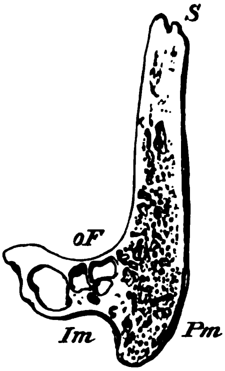


FIG. 16.

SECTION THROUGH THE MASTOID PORTION OF A MAN, AGED 30. (*Gruber.*)
S, squamous portion; *oF*, upper surface of mastoid portion; *Pm*, mastoid process; *Im*, gastric fossa. (The largest pneumatic spaces are seen to be on the inner side of mastoid process, the tissue of which is more diploetic in character.)

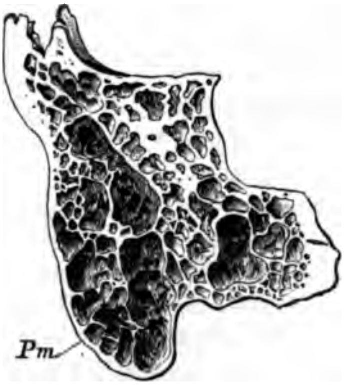


FIG. 17.

SECTION THROUGH THE MASTOID PROCESS OF A MAN, AGED 30. (*Gruber.*)
Pm, mastoid process, with the cellular spaces very well developed.

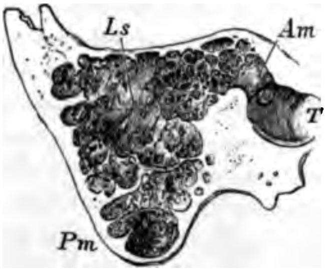


FIG. 18.

SECTION THROUGH THE MASTOID PORTION AND TYMPANUM OF A MAN, AGED 3
(*Gruber.*)
T, tympanum; *Am*, mastoid antrum; *Pm*, mastoid process with (*Ls*) pneumatic space

cells of the upper half contained air. In rare cases, the mastoid process has a single cavity in its interior; but, as a general rule, there are many cellular spaces, either communicating with each other, or shut off by *septa* composed of the lining membrane. Many variations are found to exist in the form and size of the cells; those contained in the free portion of the mastoid process

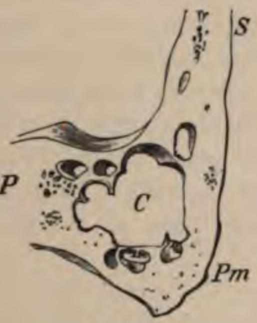


FIG. 19.

SECTION THROUGH THE MASTOID PROCESS OF A MAN, AGED 30. (*Gruber.*)

S, squamous portion; *Pm*, mastoid process; *P*, petrous portion; *C*, a large pneumatic cavity, with adjoining smaller ones.

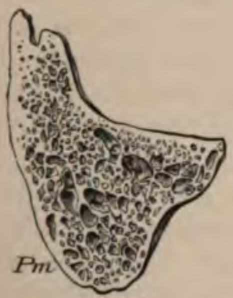


FIG. 20.

SECTION THROUGH THE MASTOID, ENTIRELY DIPLOETIC, OF A MAN, AGED 30. (*Gruber.*)

Pm, mastoid process.

are usually the largest. (See Figures 17 and 19.) The differences in the number, size, and position of the cells in different specimens are well illustrated in Figs. 16—20, copied from Gruber's work.

The relations of the mastoid cells and antrum to both surfaces of the bone are of much practical importance. On the dried bone, the upper part of the rim surrounding the meatus often presents a tubercle or spine (the *spina supra meatum*), with a small depression above, and these serve as guides to the mastoid antrum, being immediately superficial to it, and separated from it by compact and spongy osseous tissue about 6mm. in thickness. The outer layer of compact bone measures only 2mm., the remaining distance is occupied by spongy tissue, bounding minute pneumatic cells. A horizontal line directed backwards from the tubercle is always above the level of the floor of the antrum. The line of attachment of the auricle runs about 15mm. behind the tubercle, and an opening into the antrum from behind this line must take an oblique direction forwards and inwards. If made perpendicularly to the surface it will impinge upon the sigmoid groove, the bone being, on an average, 7½mm. thick at this part. This measurement, however, is subject to great variations; Schwalbe states that it has been found as low as 2mm., and as high as 15mm.

According to Dr. Macewen,* the mastoid antrum may be reached by an opening made at the base of the triangle formed by (*a*) the posterior root of the zygoma running somewhat horizontally above, (*b*) the portion of the descending plate of the squamous which forms the arch of the osseous part of the external auditory meatus below, and (*c*) a base line uniting the two, dropped from the former on a level with the posterior border of the external auditory meatus. The apex of this triangular depressed area points forwards. When the descending plate of the squamous has been penetrated through the supra-meatal triangle, the antrum is exposed near the passage communicating with the tympanum, the average distance of its deepest part from the external surface of the skull being three-quarters of an inch.

The thickness of the osseous lamella on the outer surface of the mastoid portion varies considerably. The upper part is generally thicker than the lower, and the apex is more compact than the part immediately above it. In some specimens the layer of bone is almost as thin as paper, and yields to very slight pressure. The openings often found on the surface are in part the remains of the unossified masto-squamosal suture, and in part the results of absorption of the osseous tissue. In children, the permanence of the fissure may be a matter of importance, inasmuch as the connective tissue occupying the chink might allow inflammation to extend outwards from the tympanic cavity. In the adult bone, remains of the fissure are far less common; they are found in about 2 per cent. of all cases. In the internal osseous lamella covering these cells, there are two spots, where either apertures or cracks sometimes exist, or the crust is found to be extremely thin. One of these is situated in the layer of bone continued from the roof of the tympanum to that of the mastoid antrum. This layer is sometimes perforated by several minute apertures. Similar openings are occasionally seen in the thin osseous lamella which separates the sigmoid sinus from the posterior mastoid cells. Some of these openings are traversed by minute veins, forming a communication between the sinus and the antrum. Suppuration within the mastoid process may cause necrosis of this shell of bone, with phlebitis of the sinus as a further result. Occasionally the osseous partition is defective, the wall of the sinus being then separated from the cells by a layer of fibrous membrane (Macewen).

---

* *Pyogenic Diseases of the Brain and Spinal Cord*, p. 9.

The mastoid antrum and cells are lined by a very thin mucous membrane which is closely connected with the periosteum. Minute bands and threads of membrane stretch across and subdivide many of the pneumatic cells, so that the openings between the cells appear smaller than in the dried bone. In a few cases the openings between the mastoid cells and antrum have been found closed by mucous membrane. The epithelial layer consists of non-ciliated pavement cells. Dr. Macewen states that the lower mastoid cells "are not connected with the antrum by a mucous layer, yet, in the presence of molecular disintegration, the intervening structures are destroyed, and the contents of the upper mastoid cells and the antrum penetrate into the lower ones, which become filled with granulation tissue and putrid pus."

Functions of the Mastoid Cells.—Little is known with regard to the physiological significance of the mastoid cells. According to some physiologists, the differences in the size and contents of these cells would seem to indicate that they do not subserve any very important purposes in connection with hearing. They may, however, be regarded as supplementing the capacity of the tympanum, which must not fall beyond a certain limit, if variations in pressure of a given amount are to produce corresponding vibrations of the membrana tympani. If the tympanum were reduced in size, slight excursions of the membrane would cause considerable expansive power of the contained air, and any further increase in the vibrations would be thereby checked. Moreover, for the reception of low notes, the tympanum must be of a certain depth and capacity, and hence the additional space furnished by the mastoid cells may be of considerable importance so far as these tones are concerned.*

---

* Burnett's *Treatise on the Ear*, p. 118.

CHAPTER III.

THE EXAMINATION OF PATIENTS SUFFERING FROM AURAL AFFECTIONS. GENERAL SYMPTOMS AND CAUSES.

Investigation of History of Case—Points to be Ascertained—Influence of Age, Occupation, and Surroundings—Duration of Symptoms—Injuries as a Cause—Previous Diseases—Hereditary Predisposition—Pain as a Symptom—Discharges from the Ear—Vertigo—Subjective Auditory Sensations.

In order to arrive at a conclusion with regard to the nature and probable course of many affections of the ear, it is necessary to examine not only the organ itself, but the general condition of the patient, and to make inquiry into his previous history and any subjective symptoms of which he may complain. Morbid conditions of the ear may give rise to symptoms in other parts of the body, while diseases of other organs may be the real cause of symptoms manifesting themselves in the ear. Affections of the circulatory organs and of the nervous centres are often associated with subjective auditory sensations, in the absence of any discoverable changes in the ear itself.

In the investigation of the history of the case it is well to allow the patient to tell his own story, so far as it is possible for him to do so. In dealing with children, the information must, of course, be obtained from those in charge of them. Too many questions are apt to mislead a patient, and to cause him to describe symptoms not connected with his ailment. It is obviously desirable to conduct the examination in a regular manner, asking questions in a definite order, and carefully noting down the answers.

The following are the principal points on which information should be obtained from the patient:—

1. Age, occupation, habits, and place of residence.

2. The duration of the complaint, the circumstances under which it first appeared, and its course.

3. The general health of the patient, with especial reference to any diseases from which he may have suffered, *e.g.*, scarlatina, diphtheria, measles, whooping-cough, mumps, influenza, syphilis, throat-affections, &c.

4. The occurrence of any aural affection among members of his family.

5. The nature of previous treatment (if any) of the aural affection.

6. The influence of external conditions, *e.g.*, changes of weather, &c., upon the deafness and other symptoms.

7. The presence or absence of pain, giddiness, and noises in the ears, the patient being invited to describe minutely any sensations of this kind.

8. Discharges from the ear at any time noticed; their duration, quantity, and character, and whether connected or not with pain or any other symptom.

The age of the patient determines to some extent the nature of the complaint, and is important in connection with the prognosis and treatment. Children are especially liable to suffer from inflammatory affections of the tympanum as a result of the extension of morbid processes from the naso-pharynx, and the frequent occurrence of measles and scarlatina among young subjects accounts for their greater liability to aural diseases. Between twenty and forty years of age, chronic catarrhal and suppurative affections of the middle ear are very frequent. In later life, these affections become less common, and chronic adhesive catarrh is the complaint most often met with. In old age the frequency of aural diseases is again increased; the tympanum is often the seat of chronic inflammatory processes, accompanied by thickening of the lining membrane and rigidity of the articulations of the ossicles. The auditory nerve, like other nerves of special sense, is apt to become less sensitive with advancing years. As a general rule, affections of the ear in old people are less amenable to treatment than similar diseases in young subjects.

The following are the principal results of Bezold's* investigations concerning the average hearing power of the aged; they are based on an examination of 200 persons over fifty years of age. From the sixtieth year onwards there is not only a successive decrease in the number of those with nearly normal hearing, but also a successive increase in the degree of the deafness. The female sex in old age is less able than the male to resist those influences which cause a high degree of deafness. The frequency of deafness in old age is, to a great extent, explained by the fact that the various sequelæ of former inflammatory processes are increasingly numerous from the fiftieth year onwards.

Occupations, habits, and surroundings often play a decided part in the causation of aural affections, and exercise considerable influence on their course. In one category may be grouped those occupations which involve constant exposure to the vicissitudes of the weather; and in another, those in which the auditory nerve is liable to be excited and irritated by loud and sudden noises. Thus catarrhal affections of the ear are somewhat frequent among gardeners, coachmen, and fishermen; while deafness caused by paralysis of the auditory nerve, and marked subjective auditory sensations, are often noticed among blacksmiths, chainmakers, coopers, and engine-drivers. With regard to *surroundings* and *habits*, it is well known that the development and course of many aural affections are much influenced by the patient's circumstances. Poor people living in cold damp localities are much more prone to suffer from catarrhal affections of the ear than those who are more favourably situated, and the progress of such complaints is apt to be affected in a corresponding manner. With regard to *diet* and *general mode of living*, it is certain that the immoderate use of alcohol tends to aggravate many diseases of the ear. A similar statement may be made with reference to tobacco, which sometimes causes severe and obstinate tinnitus and marked diminution of hearing power. Irritation and dryness of the naso-pharynx is another prejudicial effect; the tobacco smoke may also pass into the tympanum and produce a similar condition.

Duration of the Complaint.—The statements of the patient or his friends with regard to the duration of the complaint must be carefully sifted, inasmuch as the early stages of many diseases of the ear are unattended by pain or any marked disorder of function, and are therefore apt to be unnoticed. When the complaint is unilateral its origin is less likely to be observed, for the healthy ear may be equal to the ordinary requirements of the patient. Many people fail to notice any difference in their hearing power until marked impairment has occurred; it is only when they are unable to hear their friends' conversation, or when tinnitus becomes troublesome, that their attention is directed to the state of the faculty in question. Morbid changes requiring months, or even years, for their development are not infrequently detected in patients who assert that their complaints are of quite recent origin.

---

* *Archives of Otology*, 1894, p. 214.

Injuries.—If any injury to the ear be mentioned by the patient its nature should be carefully investigated. Blows on the side of the head have been known to cause rupture of the membrana tympani, and the complaint described as hæmatoma auris is often due to this cause. Severe injuries to the skull may involve the petrous portion of the temporal bone, and cause hæmorrhage into the middle or internal ear, besides rupture of the membrane. The latter injury is sometimes due to concussion resulting from explosion of gunpowder, but instances of this kind are not so common as is generally supposed. In the cases that have been recorded there has probably been some antecedent affection of the tympanum or Eustachian tube, preventing the free circulation of air. A rare cause of rupture of the membrane is the force of condensed air to which men working in caissons are exposed. Foreign bodies passed into the meatus may injure the membrane and set up inflammation of the tympanum. Affections of the meatus are not infrequently due to the patient's own efforts to cleanse the part or to relieve irritation, and not a few serious lesions have been caused by unskilful attempts to remove foreign bodies.

Previous Illnesses.—Direct questions should be put with regard to any previous diseases from which the patient may have suffered. Thus, it is often necessary to ask whether he has ever had scarlatina, measles, influenza, typhus, typhoid, small-pox, or syphilis, and whether he is liable to attacks of sore throat. (The connection between diseases of the throat and those of the ear will be fully discussed in a subsequent chapter.) It must also be remembered that aural affections are often connected with tubercle, less frequently with rheumatism and gout, with inflammatory affections of the lungs, and with chronic disorders of the heart and kidneys. In another class of cases, the cause of the aural affection is to be found in some cerebral lesion, such as meningitis, tumours of the brain, hæmorrhage, &c.

Hereditary Predisposition to aural diseases is sometimes traceable, the affection, however, not being always the same in the parent and offspring. Thus in the case of a child suffering from purulent inflammation of the tympanum, it may be found on inquiry that the father is the subject of chronic adhesive catarrh. A tendency to catarrhal affections of the throat is often noticed among members of the same family. Of 500 cases of middle ear disease, investigated by Bezold,* the influence of heredity was traceable in 43 per cent., and in 28 per cent. among 381 patients suffering from diseases of the internal ear. Atavism is not infrequent; and even where marked tendency exists, the aural affection may be found only in a few members of the same family. Heredity plays a very important part in the causation of congenital deafness; this fact will be fully discussed in a subsequent chapter.

External Conditions.—It is desirable to ascertain whether the complaint is influenced by certain external conditions; such, for example, as changes of weather. Catarrh of the tympanum is always made worse by exposure to cold and damp, and the patient should therefore be directed to avoid these injurious influences as far as possible. Exposure to cold, wind, and rain, is often assigned as the cause of the aural affection, and if the latter has really come on immediately after such exposure, the statement may prove to be correct. The cold may act directly upon the ear, or may affect the naso-pharynx and the Eustachian tubes. The entrance of cold water into the meatus, as in sea-bathing, is liable to cause inflammation not only of the external ear, but also of the tympanic membrane and tympanum.

The etiology of diseases of the labyrinth requires to be minutely discussed; its consideration will be deferred until the last section of this work is reached.

Pain as a Symptom.—When the patient complains of pain he should be questioned as to its character—whether it is continuous or periodic, and, if the latter, at what time it comes on. Other points in connection with pain are its limitation to the ear, or its radiation to other parts, such as the side or back of the head, the throat, and the naso-pharynx. Inquiry should also be made as to whether the pain is aggravated by coughing, swallowing, movements of the head, and by pressure. Pain is often absent in cases of chronic inflammation of the meatus and tympanum. It is nearly always severe in acute purulent inflammation of the tympanum, before the membrane has given way or been punctured. Its intensity varies in different cases of the same disease, and is sometimes very slight, even where considerable destruction of tissue has taken place. Examples of this kind are seen in tuberculous subjects. Patients frequently complain of a feeling of irritation on or below the floor of the meatus at its inner end, and express the wish to be able to scratch the spot. This irritation is due to granular pharyngitis; the offending granule, or more frequently a thickened band of tissue, being situated behind the posterior pillar of the fauces.

---

* *Münch. Med. Woch.*, 1887, Nr. 28.

Discharges from the Ear are generally caused by morbid conditions either of the meatus or the tympanum. In a small proportion of cases, they are due to lesions of the internal ear or of the intracranial structures. They vary in quantity, colour, consistence, and other peculiarities. Regarded as symptoms, they may be divided into three classes: (1) discharges consisting of mucus, serum, and pus; (2) blood, either alone or combined with more or less mucus, &c.; (3) cerebro-spinal fluid and cerebral substance. Several of these ingredients are often commingled; it will here be sufficient to indicate their possible sources.

Discharges of serum and pus from the external meatus may be due to local causes, *e.g.*, eczema and suppurative inflammation, either diffused or circumscribed; but the pus may come from a parotid abscess, or from a suppurating lymphatic gland in the neighbourhood of the ear. In a few cases, a cerebral abscess has been found to communicate with the external meatus.

The tympanum is the most frequent source of aural discharges, which pass into the meatus through a perforation in the membrane, and in rare cases through openings in the walls. Such discharges may consist of mucus, serum, pus, or blood; or of several of these constituents in varying proportions. The quantity varies greatly in different cases, and in the same case at different times; it may amount only to a mere trace, or it may be very profuse, and between these extremes there are many intermediate degrees. The consistence also varies greatly; sometimes the discharge is thin and watery, and sometimes thick and semi-fluid. The colour depends mainly upon the amount of blood and pus respectively. When these are absent, the discharge may be almost colourless. Bluish and greenish tints are noticeable in some cases. The discharge may present other peculiarities: thus its odour is sometimes very unpleasant; and it sometimes causes great irritation, and even suppuration of the walls of the meatus. The pus from a cerebral abscess may find its way into the tympanum, and thence into the meatus.

The length of time during which a purulent discharge may continue to escape is very indefinite. Intermissions and remissions are the general rule in chronic cases of middle ear suppuration. The author has met with one case in which the discharge was said to have been present continuously for fifty years, and another in which it was stated to have existed for forty-seven years. In both cases a complete cure was effected after six weeks' treatment with an antiseptic lotion and dry boric acid. In the former case eighteen months has elapsed without recurrence of the discharge, and in the latter, ten years. The risks associated with chronic discharges from the middle ear will be fully discussed in subsequent chapters.*

Vertigo.—The inquiry should further extend to other signs of nervous disorder: the occurrence of vertigo should be inquired into, and, if complained of, its characters should be ascertained, whether continuous or paroxysmal, whether excited by any special cause, and whether accompanied by vomiting.

The Condition of the Nervous Apparatus.—The condition of the auditory apparatus is the next subject for investigation, and two sets of symptoms, viz., *subjective sensations of hearing* and *impaired perception of sounds*, remain to be considered.

Subjective Sensations.—The patient's own statements are, of course, the only guide with reference to subjective auditory sensations, and are not always to be depended upon. The character, duration, and apparent place of origin are the main points to be investigated in connection with these phenomena. They may co-exist with more or less deafness, both complaints having come on simultaneously, or they may exist alone. Sometimes they are followed by deafness; in other cases a reversed order of sequence is described. Many various expressions are used by patients to describe their sensations. Thus the sounds heard are said by different sufferers to resemble the ticking of a clock, the ringing of a bell, the whistling of a steam engine, the bubbling of water, the roar of the wind, the rattle of machinery, the humming of bees, &c. Musical sounds variously combined, the sounds of instruments and of voices, the cries of animals, the singing of birds, the buzzing of winged insects, and a vast number of other sounds are declared to be perceived in the absence of any objective cause. Patients are apt to exhaust their vocabulary in attempting to describe their sensations, and not infrequently assert that they are unable to compare them with any recognised sounds.

---

* Further information on the important subject of discharges from the ear will be found in the chapters dealing with Aural Catarrh and Suppuration. Hæmorrhage from the Tympanum and the Escape of Cerebro-spinal Fluid are described in Chapter XXXVI.

In some instances the sounds are continuous, the patients declaring that they are always conscious of them during their waking hours; in other persons the sensations are troublesome only at intervals. In the former class, the intensity of the sound is apt to vary from time to time. Sometimes various kinds of sounds are perceived simultaneously, and sometimes in succession. The intensity of the sound is often affected by the position of the head, being sometimes increased and sometimes diminished when the patient is lying down. In the former case the sensation may be so intense as to prevent sleep and to cause great distress. Inquiry should be made as to the time at which the sensation was first experienced, whether it preceded, accompanied, or followed any other complaint of the ear from which the patient may be suffering, and whether any alteration has taken place in the severity of the symptom as a result of treatment or otherwise.

The locality to which the sounds are referred is another point on which inquiry should be made. In most cases the sounds appear to originate in one or both ears; sometimes they are referred to the head generally, or to some particular portions of it—*e.g.*, the occiput, or vertex. In another class of patients, the sound appears to come from some point outside the head, its direction being always the same, or varying from time to time.

In all cases in which sensations apparently subjective are complained of, the surgeon should ascertain whether any objective cause is present. It sometimes happens that the noises can be heard by other persons; in such a case, they depend upon pathological conditions in the interior of the ear, or in the Eustachian tube. Abnormal action of the muscles of the latter structure and of those of the ossicles may also cause some of these sounds. Further details with regard to subjective sensations and various modifications of the function of hearing will be given in the chapters on Affections of the Auditory Nerve.

Having thus obtained as clear an account of the symptoms as the patient is able to give, the condition of the external ear, tympanic membrane, and tympanum, and the amount of hearing power should next be investigated. The next chapter will be devoted to a consideration of the methods of examination.

CHAPTER IV.

THE EXAMINATION OF THE EAR AND DETERMINATION OF THE HEARING-POWER.

Examination of the Ear—Sources of Light—Mirrors—Use of Specula—Brunton's Auriscope—Other Forms—Methods of Using—Points to be Noticed—The Membrana Tympani, Normal Appearance—Parts Seen Through it—The Cone of Light—Mobility of Membrane—Use of Siegle's Speculum—Division of the Membrane into Quadrants—Determination of Hearing-Power—Use of the Watch—Formula for Registering Hearing-Power—Bone-Conduction—Politzer's Acoumeter—Hughes' Sonometer—Testing with High Notes—Galton's Whistle—The Tuning-Fork—Number Requisite—Speech as a Test of Hearing—Methods to be Adopted—Whispered Speech—Tests for Bone-Conduction—Use of the Watch, Tuning-Forks—Weber's Experiment—Tuning-Forks with Clamps—Rinne's Experiment—Value of Tests—Gruber's Modification—Gellé's Method.

A CAREFUL examination of the accessible parts of the ear is indispensable for the correct diagnosis and treatment of aural diseases; and the present chapter will contain a description of the manner in which such an examination is to be conducted in all its details.

Illumination of the Accessible Parts of the Ear.—The first requisite is good light, and ordinary daylight reflected from white clouds is often sufficient; but in dull weather an artificial substitute is always necessary. For a fixed light either gas or the electric light is very suitable, and for occasional use a powerful mineral oil lamp answers the purpose well. For gas, the modifications of Mackenzie's Rack-Movement Lamp (Figs. 21 and 22), introduced by the author in 1878, will be found to be very convenient, and Messrs. Mayer & Meltzer have so arranged the bracket that it can be screwed into a wall as well as used in the standard form shown in the figure. The outer asbestos cylinder shown in Fig. 22 should be fixed so that an interval of not less than three-quarters of an inch may exist between it and the metal chimney. An incandescent gas burner, fitted to a bracket of this kind, is far preferable to electric light; its illumination is as good as the latter, and, moreover, it enables mirrors and specula to be warmed without the inconvenience of having a spirit lamp for this special purpose. The light emitted will be considerably increased if the interior of the chimney be kept whitened by painting it with oxide of zinc, made into a thin paste with water. For an electric light it is best to have the lamp fixed at the end of the third arm of a similar rack-movement apparatus, and connected ls with the wires attached to the wall.

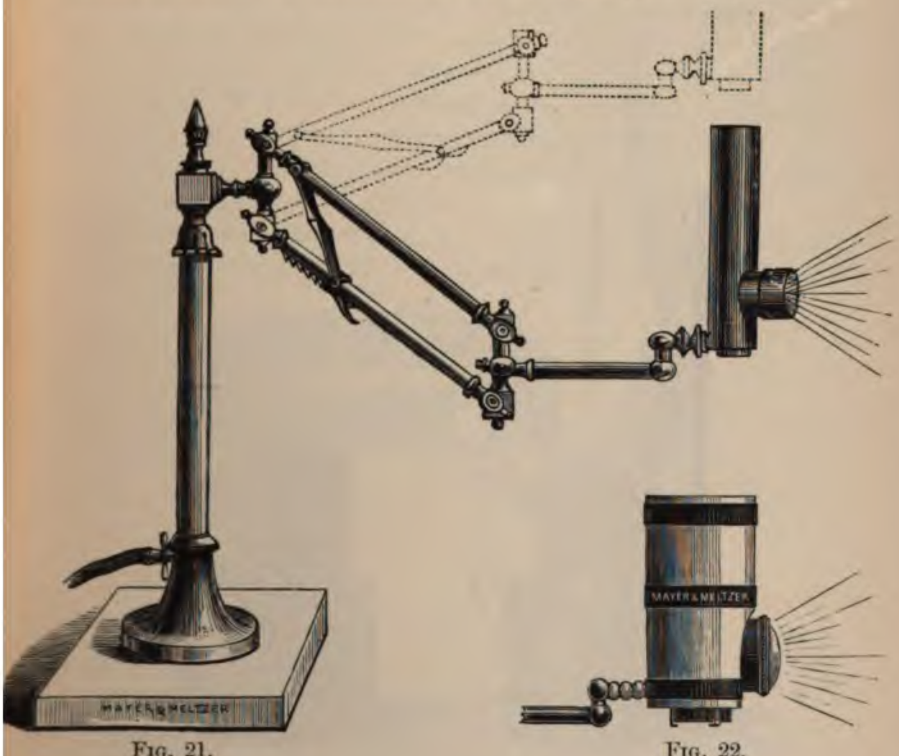


FIG. 21. FIG. 22.

THE AUTHOR'S MODIFICATION OF MACKENZIE'S RACK MOVEMENT GAS LAMP.

The modifications consist of an asbestos outer cylinder over the concentrator, to prevent the heat causing discomfort to the patient, and a third joint to the arm of the bracket, to enable the direction of the light to be altered without the heated concentrator being handled.

During the last twenty years, the author has used the portable mineral oil lamp (Figs. 23 and 24), which he was led to devise after finding that the portable lamps sold by instrument makers were practically useless, and did not give sufficient light to enable a thorough examination of the throat, nose, and ear to be made. Fig. 24 shows the metal cap screwed on to the top of the reservoir ready for travelling. To prevent the oil from splashing out of the reservoir, its surface should be entirely covered with segments of a cork, each about a quarter of an inch in thickness, and subdivided into pieces about the size of a pea. With the reservoir only three parts full, and the oil entirely covered with pieces of cork of the size mentioned, the oil will not leave the reservoir unless the lamp is overturned. In this event the leather

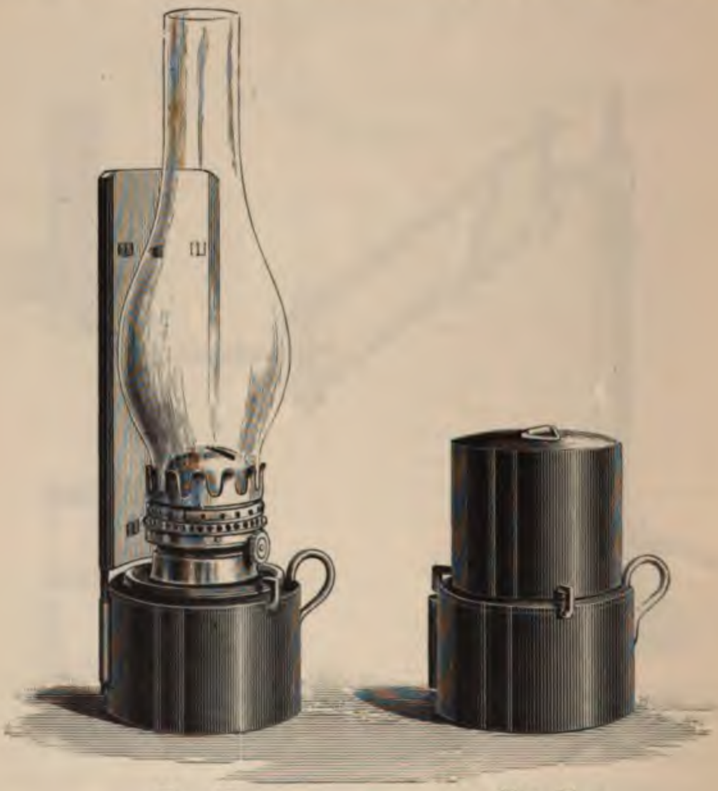


Fig. 23. Fig. 24.

THE AUTHOR'S PORTABLE LAMP.

washer between the cap and the top of the reservoir will prevent the oil from escaping beyond the cap, if the latter has been properly screwed down. The dimensions of the lamp are as follows: Height of reservoir, 2¾ inches; diameter of reservoir, 4 inches; breadth of wick, 1½ inches; total height of lamp, with cap affixed, 6 inches. The asbestos shield on the left-hand side of Fig. 23, as it is viewed from the front, protects the patient's face from the light and heat of the lamp. It may be made circular, with an opening in front to transmit the light, or bent to about three-quarters of a circle and fitted with a reflector. A flannel bag lined with wadding enables the chimney to be carried with additional safety, and allows of its being handled when hot. The lamp is made by Mayer & Meltzer.

For examining the auricle, no instrument of any kind is required; the light should be allowed to fall directly upon it.

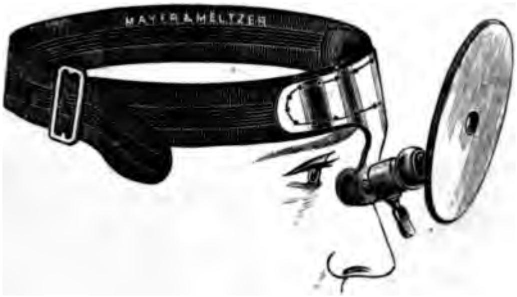


FIG. 25.

For the examination of the meatus and of the membrana tympani, it is necessary that the light should be reflected into the ear from a suitable mirror; and in order to gain a clear view of the membrane, and of the deeper portion of the meatus, it is generally necessary to employ some form of speculum. In the majority of cases, owing to the curved direction and small size of the meatus, the membrane is not visible unless a speculum be used.

For reflecting light into the meatus, a small concave mirror is required. It should have a diameter of about two and a-half inches, and a focal distance of five or six inches. In the centre is a small elliptical opening, through which the observer inspects the illuminated structures. When direct sunlight is used, a flat mirror is required, in order that the eye may not be dazzled by excessive light. The mirror may be attached either to a handle or to a head-band by means of a ball and socket joint (Fig. 25); the latter contrivance enables the surgeon to use both hands in operating upon the ear.

Fig. 26 represents the late Mr. Gardiner Brown's* hand mirror. It differs from the old-fashioned mirrors in having an elliptical opening instead of a circular one. The advantage of this is that, when the mirror is held obliquely, the sight is not interfered with by the rays of light reflected from the edges of the opening, to nearly the same extent as is the case when the opening is circular. Whilst speaking of mirrors, it is well to mention that all which are intended for aural or laryngeal use should have a perforation in the glass as well as in the metal back. Some mirrors of Continental manufacture are still made with only a perforation in the metal back, the reflecting composition being scraped off the back of the glass to a corresponding extent to allow for vision. The objection to this mode of construction is obvious.

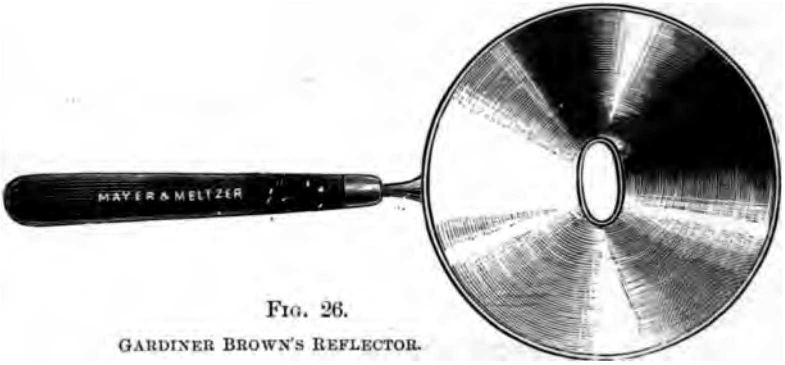


FIG. 26.
GARDINER BROWN'S REFLECTOR.

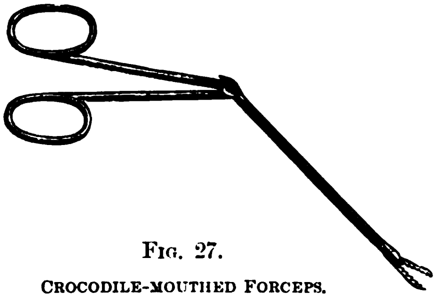


FIG. 27.
CROCODILE-MOUTHED FORCEPS.

---

* Mr. A. Gardiner Brown held the appointment of Aural Surgeon to the London Hospital from 1876 until his death in 1882.

Having thrown a strong light into the meatus, the surgeon should take the auricle between his thumb and forefinger and draw it upwards, backwards, and a little outwards, so as to diminish the curvature of the cartilaginous portion of the tube. The tragus should at the same time be drawn forwards. If, as often happens, particles of cerumen and epidermis or purulent secretion obstruct the view, these should be removed by means of forceps (Fig. 27), a fenestrated scoop (Fig. 28), a little cotton wool attached to a fine probe, or by the use of the syringe. A good light is indispensable whenever the forceps or scoop is used, and if the obstructing masses be in the deep portion of the meatus, syringing is generally necessary. The proper method of using the syringe will be subsequently described.

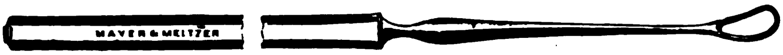


FIG. 28.

IMRAY'S SCOOP.

Ear Specula: Brunton's Auriscope.—For the examination of the membrana tympani, the best form of speculum is that which is known as Brunton's.* It consists of a plated German-silver cylinder, to one end of which an ear speculum is fitted, while at the other there is an eyepiece containing a lens. Light is admitted into the instrument by means of a funnel-shaped tube which passes into its side at a right angle, and is reflected through

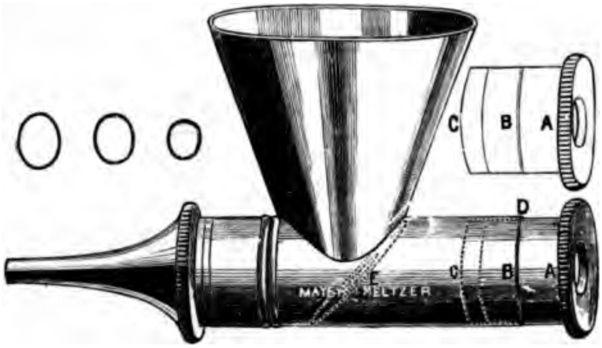


FIG. 29.

THE AUTHOR'S MODIFICATION OF BRUNTON'S SPECULUM.

* See *Lancet*, vol. ii. 1865, p. 617.

the end of the speculum by a perforated mirror placed across the cylinder at an angle of 45 degrees. Although the instrument is extremely simple in its construction, and easy to use, it was but rarely employed until 1894, when the author's modification was made public. In its original form a distinct view could scarcely be obtained. The eyepiece usually fitted so tightly into the cylinder that it could only be moved with great difficulty, and the lens had not been made to focus at any particular distance from the end of the speculum. At the author's request, Messrs. Mayer & Meltzer now make the instrument in the following manner:—A groove, B, is cut around the middle of the eyepiece, and when this groove is on a level with the end D of the cylinder, the lens C is focussed for normal vision, three-quarters of an inch beyond the end of the speculum. As the eyepiece is inserted into the cylinder for only half its length, the remaining half A can be pushed in until the light is focussed on the membrane, or the half of the eyepiece in the cylinder can be pulled out to the necessary degree to obtain a distinct image for an eye that is not emmetropic. The tube at the side has been made funnel-shaped, as shown in Fig. 29, instead of being a narrow cylinder expanding externally into a trumpet-shaped orifice. It is obvious that the present-shaped opening admits more light than the one which was formerly in use. The inner surface of the cylinder and speculum end should be dull black, and it is essential for the portion of the cylinder between the lens and the oblique perforated mirror to be of that colour. The speculum may be used with either daylight or artificial light; but except with sunlight, or on a very bright day, the latter gives the better illumination. A rack-movement lamp is always to be preferred, and the bullseye condenser should be placed against the funnel-shaped opening, in the side of the instrument; by means of the light thus introduced into the speculum a very distinct magnified view of the membrana tympani can be obtained. The lens which is now used has a magnifying power of three diameters at its focus. Whilst the examination is being made the patient should be seated, and if a lamp be used, the burner should be on a level with his ear. With his left hand, the surgeon draws the auricle upwards and backwards, and then passes the speculum slowly, and with the utmost gentleness, into the meatus, keeping the tube of the instrument against the roof of the canal. If the inward movement of the speculum be impeded, or if pain be caused, the tube should be slightly withdrawn, and the wall of the meatus examined. It will, perhaps, be found that a smaller speculum is necessary. Three specula of different sizes are usually supplied with each instrument; but a fourth, of a still smaller size, is required for examining children. As a general rule, it is well to use the largest speculum that can be introduced without difficulty.*

The objection has been raised that Brunton's speculum is suitable only for purposes of diagnosis and not for manipulation or operation. But for diagnostic purposes it is surely no small advantage to obtain the best possible view of the object to be examined; and if lesions be detected requiring operations of any kind, an ordinary form of speculum can be employed. In such a case, however, the previous inspection of the parts through a magnifying lens is a decided gain, and Brunton's speculum certainly helps to make diagnosis easier and more accurate. With regard to all specula, it must be remembered that their introduction sometimes causes a troublesome reflex cough, owing to irritation of the auricular branch of the pneumogastric nerve.

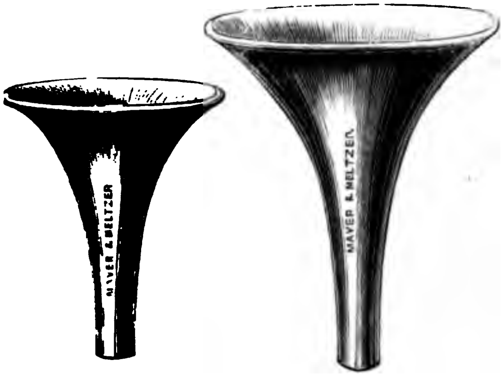


FIG. 30.
DALBY'S SPECULUM.

The more simple forms of Specula are too well known to require minute description. Different surgeons hold different opinions as to the most convenient shape, some preferring a funnel-shaped tube, and others a somewhat conical form. Then, again, vulcanite specula have their advocates, while silver or plated instruments are preferred by some authorities. The kind of speculum which he has often used is apt to be regarded by the surgeon as the most convenient and the best adapted to its purpose. For operative work the author uses a Dalby's speculum (Fig. 30), 1¾ inches in diameter, *i.e.*, rather wider than its original size. Metallic specula are less liable to be damaged; but the black internal surface of the vulcanite instrument serves to render the membrana tympani more distinct by contrast with the dark margin that surrounds it. By reflecting the light, metallic specula help to illuminate the membrane and meatus; sometimes the view is rendered indistinct by such reflection. Vulcanite instruments have the advantage of being lighter and warmer, and their introduction is therefore less unpleasant to patients.

---

* Since the first edition of this work was published, several practitioners have informed the author that they have tested a Brunton speculum made according to his recommendation, and that they have continued to use it, having found that a very much better view could be obtained than with an ordinary speculum. They had previously tried a Brunton speculum, and had laid it aside as useless.

Specula are usually made in four sizes adapted to the varying calibres of the meatus in different persons. When a metallic instrument is used, care should be taken that the edge of the tube introduced into the canal is rounded off and blunt, for if it be very thin and sharp, it is apt to scrape or cut the skin of the meatus, and cause bleeding and pain. The bivalve speculum, formerly much employed, has no advantages to recommend it. A metallic speculum should always be warmed before it is introduced into the meatus.

Introduction of ordinary Speculum.—If the ordinary instrument be preferred, it should be employed in the following manner:—When there is sufficient daylight, the patient should be seated near a window, with the ear about to be examined turned away from the light and directed slightly upwards. The surgeon should also be seated, so that he can look directly into the patient's ear. When a lamp is requisite, it should be placed a little behind the patient's head, and so arranged that the light may fall upon the mirror at an angle of 45°, and thence be reflected into the meatus. The auricle is then taken between the index and middle fingers of the left hand, and drawn upwards, backwards, and outwards, and examined with the aid of the mirror. If the meatus be free from obstruction, the examiner takes the speculum between the thumb and first two fingers of the right hand and passes it gently and with a slight rotatory movement into the meatus, keeping the instrument against the upper wall of the canal. The thumb of the left hand keeps the speculum in position, while the surgeon takes the mirror, brings it to within five or six inches of the patient's ear, and looks through the opening in the glass. By causing the right and left hands to work together, the one moving the mirror and the other the speculum, the membrana tympani is brought fully into view. It must be remembered that the size and curvature of the meatus vary in different individuals, and that it may be impossible to gain a view of more than a portion of the membrana tympani. In some persons, the anterior wall projects considerably, and obstructs the view of the anterior and lower portion of the membrane. In such a case the smallest speculum should be employed and carefully moved in different directions.

Parts to be examined—the Auricle, Meatus, and Membrana Tympani.—In examining the external ear and the membrana tympani, the following are the points to be noticed: the state of the auricle and the surrounding parts, especially of the mastoid region and of the tissues in front of the tragus and below the lobule. Next comes the external auditory canal, its calibre, direction, condition of its wall, presence or absence of cerumen, epithelial débris, purulent or mucous secretions, growths of any kind, and of foreign bodies. When the membrana tympani comes into view, its position, direction, colour, degree of transparency, form, size, curves, and the degree in which it reflects the light, are the first points to be observed. The normal membrane has a polished and shining appearance, and a pearl-grey or neutral grey colour, to which a slight brownish yellow tinge is sometimes superadded. The kind of light employed tends to modify the colour of the membrane ; artificial light gives it a reddish-yellow tint. In children, the membrane is often dull and somewhat opaque, owing to the thickness of the outer layer. But the latter may be very thin and delicate, in which case the membrane will be remarkably transparent, so that the promontory on the inner wall of the tympanum will be seen through it. In adults, the grey colour is most decided in the anterior portion, in front of the handle of the malleus, and less marked in the posterior portion. In old age the membrane often loses its lustre and assumes a dull, uniformly grey tint.

Near the upper part of the circumference of the membrane is a small prominence caused by the short process of the malleus, which appears as a yellowish-white knob, projecting into the meatus. From this process, a yellowish-white streak or ridge, due to the attachment of the handle, runs downwards, backwards, and slightly inwards, and terminates in a rounded or flattened extremity in the lower half of the membrane. This extremity corresponds with the umbo of the membrane, and from it the so-called "cone of light" extends downwards and forwards almost to the periphery. At the umbo the membrane is decidedly opaque; according to Politzer, this appearance is due mainly to the deposit of small cartilaginous cells round the inferior extremity of the handle of the malleus. At the periphery, the tympanic membrane has a decidedly white tint, due to the tendinous ring, which is more or less sharply defined, and is most conspicuous in the posterior superior portion. The yellowish-white knob, with the streak running downwards, the umbo, and the cone of light are the most prominent features connected with the membrana tympani; in some cases other structures contained within the tympanum come into view. Thus, the long process of the incus may appear through the membrane as a whitish streak, running behind the handle of the malleus; with increased concavity of the membrane, the chorda tympani may become visible, and sometimes the fenestra rotunda appears as a dark spot in the inferior and posterior portion. Extending from the short process of the malleus are two folds, one larger and more distinct, passing backwards at a right angle, and the other forwards to the periphery. These folds form the lower boundary of the membrana flaccida.

The cone of light has been already referred to in the account of the anatomy of the tympanum. It requires a somewhat minute description, inasmuch as it is subject to many variations, under both normal and pathological conditions. This "cone" or bright spot is triangular in shape; the apex commencing below and in front of the umbo, while the base is close to the periphery. Over this triangular spot, the ordinary lustre of the membrane is seen to be exaggerated, the difference varying in degree according to the condition of the membrane, its inclination and curvature, and the permeability of the Eustachian tube. Sometimes the brightness is interrupted by an opaque streak, running either longitudinally or in the opposite direction; sometimes the brightness is confined to the more central portion, and is indiscernible elsewhere.

Politzer has shown that the cone of light is due to the inclination of the membrane to the axis of the meatus, and to the concavity produced by the traction of the handle of the malleus. When examined with the speculum and mirror, the anterior portion is opposite to the eye, and directly reflects the light thrown upon it. The portion in which the bright spot appears forms an angle of 45° with a vertical plane and of 10° with a horizontal one. When air is forced into the tympanum the cone is more clearly seen; on the other hand, the brightness diminishes when the membrane is drawn inwards. Hence a change in the appearance of the cone is a sign of the permeability of the Eustachian tube; but the latter condition may exist in the absence of any visible alteration. Abnormal conditions of the tympanic membrane will be described in a subsequent chapter.

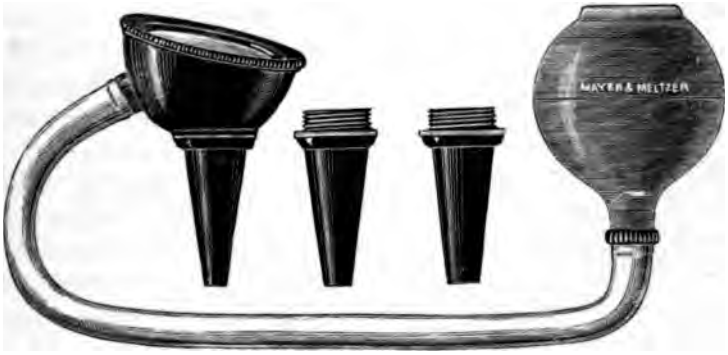


FIG. 31.

SIEGLE'S PNEUMATIC SPECULUM.

Mobility of the Membrana Tympani; Siegle's Speculum.—It is often important to determine the mobility of the membrana tympani, and for this purpose Siegle's pneumatic speculum is employed. This instrument (Fig. 31) has its wide extremity closed by means of a thin plate of glass, inserted at an angle of 45°. Near the glass plate a small nipple projects from the side, and over this an india-rubber tube, connected with a bag at its other extremity, is closely fitted. In order that the speculum should fit closely into the external meatus, a piece of india-rubber tubing is fastened around it. To examine the membrane, the speculum is passed into the meatus and held firmly with the left hand. Light is then thrown upon the membrana tympani by means of the concave mirror attached to the forehead, while the air in the meatus is alternately condensed and rarefied by compressing and releasing the ball with the right hand. Care should be taken to pass the speculum into the osseous portion of the meatus, for the walls of the cartilaginous part would be drawn inwards by the expansion of the ball, and would obstruct the view. Before introducing the instrument, the ball should be partially emptied of air. In order to obtain an enlarged view of the membrane, a lens may be substituted for the plate of glass closing the wide extremity, or may be inserted into the tube.

Under normal conditions, when air is injected by compressing the bag, the membrane is observed to move inwards, and the cone of light becomes smaller and less conspicuous. When the bag is allowed to expand, the membrane moves in the opposite direction, and the cone becomes brighter and more prominent. Siegle's method is especially valuable in cases in which the Eustachian tube is obstructed. It enables the surgeon to determine whether the membrane is adherent to the inner wall of the tympanum, and to estimate the degree of mobility of the handle of the malleus. As a result of adhesive inflammation of the tympanum, the articulation between the malleus and the incus is liable to become anchylosed, and the mobility of the membrane and of the chain of bones is thereby considerably impaired.

For the accurate description and record of changes observed, the membrana tympani may be conveniently divided into segments and quadrants. The following divisions are suggested by Urbantschitsch:—A line corresponding with the handle of the malleus is extended to the periphery, thus dividing the membrane into an anterior and posterior portion. Another line, at right angles to the first, and dividing it into two equal parts, will mark off an upper and a lower segment. The membrane is thus divided into quadrants, two of which (upper and lower) are anterior and two posterior. The cone of light is in the anterior inferior quadrant; the vertical process of the incus is sometimes visible in the posterior superior quadrant.

DETERMINATION OF THE HEARING-POWER.

The limits of auditory perception—viz., the range of vibration frequency within which tones are audible as such—vary considerably in different individuals. According to Preyer, the limit of the perception of the lowest audible tone lies between 16 and 23 vibrations per second, and e^8 with 40.960 vibrations as the highest audible tone (Landois and Stirling). According to Zwaardemaker,[*] the average upper limit in youth is at e^7 (20,480); in advanced age, at a^6 (13,653). The extreme limit of normal hearing in old people may be taken as g^6 (12,288). Any lower limit may be regarded as indicating some pathological condition.

It must be remembered that sonorous vibrations reach the extremities of the auditory nerve by two channels: (1) Air-conduction; the vibrations of the atmosphere are communicated to the air in the external meatus and thence to membranous, bony, and nervous structures belonging to the tympanum and labyrinth. (2) Bone-conduction; vibrations pass direct through the bones of the head to the fluids within the labyrinth. The degree of conduction by each of these channels is to be ascertained in the manner about to be described.

In order to ascertain the amount of hearing-power for sounds transmitted by the air, three tests are usually adopted, viz., (1) simple sounds, such as the tick of a watch, or those emitted by some specially constructed instrument; (2) ordinary conversation and certain modifications; and (3) the tuning-fork. These tests are admittedly imperfect; they do not measure the precise amount of functional disorder, but they are of great practical value in many cases. Moreover, the statements of patients when these tests are employed are more to be depended upon and can be more easily checked than their description of sensations. In testing the sharpness of hearing for any special sound, *e.g.*, the ticking of a watch, it is necessary to use the same instrument again and again under precisely similar conditions before arriving at a positive conclusion.

The watch is the most convenient instrument for testing the hearing power, but it yields only two not very definite sounds. It is, however, easily handled, and the sounds themselves emitted by any one watch are of almost constant intensity; as a general rule, after winding-up, the tick is somewhat louder than before. Different watches vary in the sounds they emit, and for testing purposes one having a sharp distinct sound is preferable; but any watch will do for the purpose, provided the distance is known at which it is heard by an ear presumed to be normal. A stop-watch is particularly useful; it enables the surgeon to test the accuracy of the patient's statements.

---

[*] *Archives of Otology*, 1894, p. 232.

The method of using the watch is as follows:—The patient is directed to shut his eyes, or to hold up a piece of paper or a fan to prevent the watch from being seen, and to close with the finger the meatus of the ear which is not being tested; the watch is then held at the extreme distance at which its sounds can be perceived by a person with good hearing power, and gradually brought nearer to the patient, who is asked from time to time whether he hears the sound. When the reply is in the affirmative, in order to see whether the patient adheres to his first statement, the watch is moved again towards the ear from a distance, the position at which its tick was heard being marked by the forefinger of the hand not holding the watch being held in that place. This procedure should be repeated several times, the patient's eyes being of course kept closed. It is unadvisable to begin the examination by placing the watch so close to the ear that its sound can be perceived; the auditory nerve, once excited by a distinct sound, is more readily affected by it for some little time afterwards. If, therefore, the examination be commenced with the watch held close to the ear, the patient is likely to be credited with more hearing-power than he really possesses.

The distance at which the watch is heard should be accurately measured and noted down for future guidance. A useful formula for registering the hearing-power has been suggested by Dr. J. S. Prout,* Surgeon to the Brooklyn Eye and Ear Hospital. The hearing-power he records "as a fraction, the numerator of which is the distance at which the particular sound is heard, the denominator the distance at which it should be heard by an ear of good average hearing power." The denominator varies according to the watch or other instrument used, and is expressed in inches. Thus, supposing that a given watch can be heard by a normal ear at thirty-six inches distance, and by the ear of a patient under examination at only six inches, his hearing-power would be expressed by the fraction $\frac{6}{36}$. If the patient hears the watch only when in *contact* with the ear, the formula $\frac{c}{36}$ may be employed, and if not at all, $\frac{0}{36}$.

---

* *Boston Med. and Surg. Journal*, Feb. 29, 1872.

Politzer's Hörmesser, or Acoumeter.—The fact has been already alluded to that different watches vary considerably in the pitch and intensity of their sounds, and to get rid of these imperfections Politzer* has invented an instrument termed a *hörmesser*, or acoumeter. This instrument consists of a horizontal steel cylinder (*c*) rather more than an inch long, and one-fifth of an inch thick, firmly connected by means of a screw with a perpendicular rod made of vulcanite (*h f*). Above the place where the cylinder is attached, a percussion hammer (*k e*) is fastened; this latter is movable upon its axis, and produces the sound by falling upon the steel cylinder. The intensity of the sound depends upon the height from which the percussion hammer falls; and in order that this height should be the same in all instruments, a small piece of vulcanite (*d*), furnished with a soft india-rubber plate, is attached to the posterior periphery of the rod as a check upon which the posterior short arm of the percussion hammer is pressed down with the middle finger. At the upper and lower

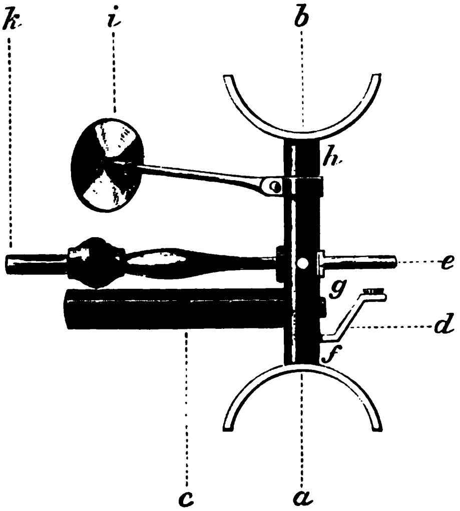


FIG. 32.
POLITZER'S ACOUMETER.

---

* Politzer, *Lehrbuch der Ohrenheilkunde*, Aufl. II. S. 106.

extremity of the rod is a flat semi-circle (*b a*), adapted to receive the forefinger and thumb by which the instrument is held. Below the upper semi-circle is an india-rubber rod, 4cm. ($1\frac{3}{5}$ inch.) long, and terminating in a circular metal plate (*i*). This last contrivance is for testing the perception through the cranial bones, for which purpose the meatuses are closed, and the metal plate is brought into contact with the temple or the mastoid process. In the same manner, in cases in which the sound of the instrument is not heard at the shortest distance from the ear, the round metal plate is made to touch the orifice of the external meatus, in order to discover whether the sound is then perceived.

The sound produced when the hammer strikes the cylinder corresponds with the note c^2 (=528 vibrations), and may be compared with the ticking of a loud watch. In using the acoumeter, attention must be paid to the position in which it is held, and the direction in which the sounds strike the ear. As a general rule, the sounds are heard more distinctly, and at a greater distance, when the instrument is held somewhat in front of the ear than when it is placed in a line with the meatus. When the hearing power is to be tested, the acoumeter is taken between the forefinger and thumb of the right hand, and the middle finger presses down the short arm of the lever, and thus raises the percussion hammer. Removal of the finger allows the hammer to fall upon the steel cylinder, and a sharp click is thus produced. The patient's eyes should be closed while the instrument is tried at gradually lessening distances until its sound is heard. Each ear must be separately tested, the opposite meatus being closed by the finger while the examination is going on.

Politzer states that the average normal hearing distance for his acoumeter is about sixteen yards, and that several advantages are connected with the use of the instrument. By reason of the greater intensity of its sound, the results obtained admit of a more definite comparison with the results of whispered speech than is the case when the watch is used; and therefore that when the hearing distance for the acoumeter is increased in any given case, a corresponding increase in the hearing distance for speech can be more surely inferred to exist. If the instruments are constructed exactly according to directions, a uniform sound is always produced. Moreover the sounds can be made to follow each other rapidly or slowly, regularly or irregularly, as the surgeon chooses, and by making the patient count the clicks, his statements as to his hearing-power can be easily tested.

In estimating the results of examinations with the view to test the sharpness of hearing, it must be remembered that in this latter respect considerable differences are liable to exist in the same patient on different days, and also at different times of the same day. Hearing power is also influenced by the temperature and moisture of the air, and by various bodily and mental conditions. It is usually better when the weather is warm, dry, and still, and when the patient's general health is good, than under opposite conditions.

Hughes' Sonometer is another instrument by means of which the hearing power can be tested, and variations while under treatment accurately estimated. It consists of two Leclanché cells, and an arrangement whereby the current can be rapidly interrupted. There is a rectangular bar, about 25cm. in length (10 inches), and divided into centimetres and millimetres, and along this slides a reel wound round with insulated copper wire. At each end of the bar is another reel, also carrying wire, but firmly fixed, and these wires are connected with the Leclanché cells. The ends of the wire on the movable coil pass through the base of the instrument to terminals, and thence to a telephone which is applied to the patient's ear. When the movable coil is placed at zero, no sound is heard; but as it is slid along the bar towards the fixed coil on the left hand, the interruptions in the current produced by the microphone are heard in the telephone. When the instrument is used, the telephone is applied to the patient's ear, and the coil placed at zero. It is then gradually slid along the bar until the patient states that he hears the sound. The distance from zero in millimetres is then noted, and the other ear is similarly tested. The value of this instrument consists in the facility with which variations in hearing-power can be detected, so far, at least, as its sound is concerned. But it must be remembered that an improvement demonstrated by this instrument does not necessarily imply any corresponding variation in hearing-power as regards speech.

Testing with High Notes, Galton's Whistle.—It is sometimes desirable to test the hearing power for very high notes. This varies considerably in different persons, and is generally much diminished in advanced life. Galton's whistle (Fig. 33) is a convenient instrument for measuring the upper limits of auditory perception. It consists of a brass tube, with a diameter of less than $\frac{1}{10}$ of an inch. The lower end is fitted with a plug, whereby the tube can be lengthened or shortened, and the pitch of the note correspondingly changed. Galton's whistle has a compass of more than the three highest octaves, and its notes correspond to 6,461–84,000 simple vibrations in a second. It is very difficult to test unilateral impairment of hearing by its means, inasmuch as its sounds are heard by the normal ear even when the meatus is thoroughly closed.

With regard to the alterations in the hearing-powers for high and low notes, it may be stated in general terms that in affections of the middle ear the perception of high notes is less interfered with, while that of low notes is apt to be retained in disorders of the internal ear. There are, however, frequent exceptions to this rule. As pointed out by Politzer, very high notes are often distinctly perceived in cases of severe disorder of the labyrinth, while low notes may be distinctly heard when there is considerable interference with sound-conduction. Diminished perception of high notes is not a positive indication of disorder of the nervous apparatus, for it often accompanies general impairment of hearing in cases of adhesive affections of the middle ear.

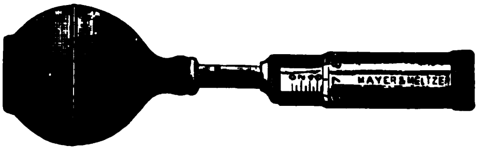


FIG. 33.

GALTON'S WHISTLE.

Speech is the most important test of hearing-power. The human voice is capable of exhibiting great variations in pitch, intensity, and quality. Moreover, deaf persons most frequently seek advice because they are unable to hear what other people say, and the removal of this disability is the object of their desire. There is another advantage in the use of speech as a test. When the patient states that he can hear words uttered to him, the accuracy of his statement can easily be tested by causing him to repeat them.

In testing by means of speech, the patient should be placed at a distance of several yards from the examiner; his eyes should be closed, and the opposite ear should be carefully stopped with a moistened finger. It is very important that the patient should not see the lips of the speaker, inasmuch as deaf persons often attain great skill in the art of lip-reading. It is well to begin the examination by testing both ears together, even when the complaint is supposed to be unilateral. It must be borne in mind that great differences often exist between the hearing capacity for speech, and that for the watch and musical sounds. In one class of cases, the ticking of a watch can be heard only when the sound is produced close to the ear, whereas a whisper is audible at some yards' distance. This difference is often found among elderly persons. In another class, the watch is heard at a distance, but speech only when the mouth is brought close to the auricle; and it sometimes happens, that when the impairment is bilateral, speech is heard best on one side and the ticking of a watch on the other. These varieties in the symptoms may be explained by supposing that the faculty of hearing various notes and sounds, and of distinguishing between them, is impaired or destroyed by morbid processes in various parts of the organ of hearing.

Words to be used in testing Hearing-Power.—It is not a good plan to ask the patient questions, for he may hear some of the words and guess at the rest. The best mode to adopt is to pronounce single words, and to tell the patient to repeat them. The most suitable words to begin with are those which contain the soft vowels and the less pronounced consonants; and if these are not heard, others should be tried. Oscar Wolf has pointed out that the vowels possess the greatest volume of sound, for they are heard at the greatest distance, while that of consonants is much less in degree. Wolf's investigations show the relative distances at which the vowels and consonants can be heard when loudly uttered. A (as in father) can be heard at 360 paces; O, at 350; E, at 330; U, at 280; S, at 175; R, at 90; F, at 67; T, at 63; B, at 18; and H aspirate, only at 12 paces. Owing to the great differences in the volume of sound possessed by the various letters, different words will be heard more or less clearly. As a general rule, whispered speech is the most suitable for testing the hearing; it is more likely to be uniform, and the difference between the sound of consonants and that of vowels is considerably reduced as compared with loud speech. It is not infrequently noticed that deaf people hear a moderately loud voice better than a *very* loud one; and this difference, according to Wolf, is due to the fact that in loud speech the sound of the vowels alone is intensified, while that of the consonants, which cannot be made much stronger, is quite drowned. For testing by whispers in an ordinary room, it has been suggested to place the patient with his face towards the wall, while the surgeon stands in a similar position near the opposite wall. If the whispers be not heard, the distance is reduced; and if the result be the same, the surgeon turns his face towards the patient. As a final test, the patient is directed to turn round, and the whispers are uttered close to his ear.

When one ear is normal, it is difficult to gauge the amount of deafness, as sound-waves are conducted through the bones to the healthy organ even after the meatus is closed. In order to determine by which ear the sound is perceived, it is well to close, not only the one supposed to be normal, but the other which is being examined. If the sound be still perceived with the same amount of distinctness, it may be assumed that it has been heard by the normal ear; but if a difference be noticed, it is clear that the test has been applied to the affected organ.

The tuning-fork is also used as a test of the hearing-power; but, as will shortly be described, this instrument constitutes the best appliance for testing the perception of sonorous undulations conducted to the ear through the cranial bones, and it is mainly employed for this purpose. When used as a *test for hearing*, the tuning-fork is caused to vibrate by striking it on the left hand or arm, or side of the knee; it is then held at varying distances from the ear. The tuning-fork generally used yields 264 double vibrations per second, and corresponds with the middle c. In testing the perceptive capacity for lower and higher notes, it is necessary to use tuning-forks of a corresponding pitch. For diagnostic purposes, Hartmann recommends five tuning-forks, corresponding with the notes c, c^1, c^2, c^3, and c^4, respectively. The first of these yields 132, and the last 2,112 vibrations per second. It is desirable to ascertain, not only the distance at which the tuning-fork can be heard, but also the number of seconds during which its sound is perceived. The value of the tuning-fork for testing the hearing-power is due to the facility with which it can be utilised for both these purposes. Conta[*] suggested that the handle of the fork should be connected with the patient's ear by means of an india-rubber tube, and Urbantschitsch[†] recommends, as a further improvement, that the tube should be T-shaped. One branch is placed in the ear of the patient, and the other in that of the surgeon, who (supposing that his hearing be normal) is enabled to measure the defect by noting the time during which he hears the sound after it has ceased to be audible by the patient. If the tuning-fork be struck with great force, the duration of the vibrations will be somewhat increased; but the difference in this respect is never very great.

Bone Conduction of Sounds.—Having determined the perceptive capacity for sounds conducted by the atmosphere to the membrana tympani, and thence to the labyrinth, the degree in which sounds are transmitted through the cranial bones to the organ of hearing is the next subject for investigation. The instruments employed for testing this latter channel of conduction are the *tuning-fork*, the *watch*, and the *acoumeter*. When vibrating bodies are placed in contact with the bones of the cranium, the vibrations reach the labyrinth by two routes—viz., by direct conduction by the solid parts, and by transmission through the bones of the head to the membrana tympani and ossicles, and thence to the sentient structures of the internal ear. Conduction through the bones is, however, far less effective than conduction by the atmosphere to the external auditory meatus. If a vibrating tuning-fork be kept on the vertex until its sound is no longer heard, its tone again becomes audible when it is brought near the ear.

The tuning-fork is the most convenient and important instrument for testing the conduction of sound through the bones of the head. Weber's experiment is utilised for purposes of diagnosis. When a vibrating tuning-fork is placed on the vertex, or in contact with the middle incisors, and the meatus on one side is closed with the finger, the sound is perceived with exaggerated intensity by the occluded ear; if both openings are closed, there is an increase of sound in both ears. A similar exaggeration of intensity is found to exist in affections involving one ear, and interfering with the conduction of sound to the labyrinth. Such interference may be due to disorder situated either in the external or middle ear, and exaggerated intensity will be noticed in both cases, provided that the sentient apparatus be in a normal condition. If disease exist in the sound-conducting apparatus on both sides, but in unequal degrees, the exaggeration will in most cases be especially pronounced in the more seriously affected ear. On the other hand, in partial deafness due to affections of the auditory nerve, supposing that the sound-conducting apparatus be not implicated, a tuning-fork placed between the incisor teeth or on the vertex will be best heard by the non-affected ear.

---

[*] *Arch. f. Ohr.*, Bd. I. S. 107.

[†] *Lehrbuch der Ohrenheilkunde*, S. 37.

In testing bone conduction, it is well to be provided with tuning-forks of various forms and sizes, and with corresponding differences in the intensity and pitch of the notes. Large tuning-forks, yielding middle and low notes, are the most useful; but it is also necessary to test the perception of high notes. Of those recommended by Hartmann, three are mentioned by Politzer as sufficient for all practical purposes. These yield the notes c (132 vibrations), c^2 (528), and c^4 (2,112), respectively. When a tuning-fork is caused to sound, over-tones are heard in addition to the fundamental note. High over-tones are discordant with each other, but are continuous and of equal intensity with the primary note. Hence it is that some confusion may arise in using the tuning-fork as a test for hearing if, as sometimes happens, the note be perceived by one ear and the over-tones by the other. To remove this source of error, Politzer recommended that each prong of the fork should be furnished with a movable brass clamp, capable of being tightly fixed by means of a screw. These clamps prevent, to a great extent, the addition of over-tones, and they have also another effect—viz., that of lowering the fundamental note. By moving the clamps the pitch of the note is changed; it becomes higher when they are moved gradually downwards, and lower when they are pushed upwards. The degree of difference in the pitch is also influenced by the weight of the clamps; the highest note is the fundamental sound of the tuning-fork, the lowest depends upon the weight of the clamps, as well as upon their position. Politzer* now recommends tuning-forks without clamps, but "having the prongs filed down near the place where they bend thinner than at their extremity. In these tuning-forks, when struck on some soft substance, there are no over-tones perceptible."

---

* Translation of Third Edition, p. 132.

In using the tuning-fork for testing bone conduction, the instrument is struck against the hand or side of the knee, and the end of its handle is then applied to the vertex, or placed between the middle incisor teeth in the upper jaw. In a case of one-sided deafness, the discovery that the note is more distinctly heard on the affected side shows that the impairment is due to some impediment to the conduction of sound through the meatus. The greater the difference, the greater the confidence with which this opinion may be expressed. If the sound be more clearly heard by the normal ear, or on the least affected side in bilateral deafness, the diagnosis cannot be made with an equal degree of certainty, for there may be either some affection of the middle ear or some disorder of the labyrinth. If the functions of both auditory nerves are impaired, the tuning-fork on the vertex will be heard less distinctly in both ears, and in severe lesions will not be heard at all. When the perceptive capacity of the nerve on each side is the object to be determined, the tuning-fork should be applied to the temple or to the mastoid process, and the surgeon may estimate the patient's hearing-power, as regards duration of sound, by comparing it with his own, assuming that his auditory nerves are in a normal state. The usual plan is that the surgeon transfers the tuning-fork to his own mastoid process immediately the patient signifies that he fails to hear the sound. If it be still perceived by the surgeon, it may be inferred that the auditory

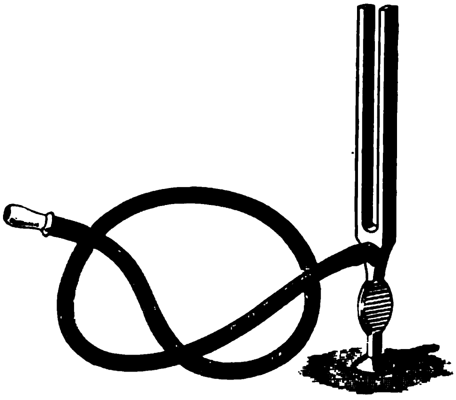


FIG. 34.

GARDINER BROWN'S TUNING-FORK, FITTED WITH TUBE AND EARPIECE, AS USED BY THE AUTHOR.

nerve of the patient is not in a normal condition. In cases in which the patient's statements vary as regards the time during which a tuning-fork can be heard by bone conduction, the author has for some years used a tuning-fork (Fig. 34) with a small projection attached to its stem, to which is fixed a piece of india-rubber tubing about two feet in length, having an ivory ear-piece at its other end. By placing the ear-piece in his own ear, and the handle of the instrument on the mastoid process of the patient, the surgeon is able to ascertain whether the vibrations are audible after the patient has stated that he can no longer hear them; and by removing the ear-piece from his own ear when the patient indicates that the sound has ceased, and placing the base of the tuning-fork on his own mastoid process, he is enabled to estimate the patient's deficiency by bone conduction, by noting the number of seconds during which the vibrations can still be perceived. A hyperæsthetic condition of the auditory nerve can also be detected by this means.

Application of Rinne's Test, Positive and Negative Results.—Reference has been already made to another experiment devised by Rinne, in 1855, and utilised for purposes of diagnosis. He found that if a vibrating tuning-fork were held against the incisor teeth until its sound was no longer heard, it again became audible when the instrument was placed near the external meatus. Conduction through the latter is therefore more effective and of longer duration than through the bones of the head. When in any given case the result is as above described—that is, when the tuning-fork is heard near the ear after it has ceased to be perceived through the bones—the test is said to be "positive." This result can always be obtained when the hearing apparatus is in a normal condition. When, however, the note is heard more distinctly and for a longer time through the cranial bones, the result is described as "negative" in character, and it points, in a general way, to some affection of the sound-conducting apparatus. This experiment, therefore, offers a means of distinguishing between affections of the middle ear and disorders of the auditory nerve; but in order that a true inference may be drawn, it requires to be considered in connection with the degree of deafness as regards speech and with altered perceptive capacity for various notes.

According to Politzer, Rinne's test is of especial diagnostic value in cases of chronic middle-ear disorders, the nature of which cannot be clearly determined by other means. In such cases a "negative" result may be taken as indicative of some obstacle to sound-conduction, and the longer the tuning-fork can be heard through the bones as compared with aërial conduction, the greater the probability that the diagnosis is correct. If the hearing-power be much impaired, and Rinne's test give a "positive" result, disorder of the nerve may be assumed to exist, but only when other symptoms and the history of the case point in the same direction. In employing this test, the vibrating tuning-fork should first be placed on the mastoid process, and subsequently in front of the ear; the difference in favour of aërial conduction should be noted in seconds. In all cases, after employing the test in the usual manner, it is well to apply the tuning-fork in the reversed order—*i.e.*, to hold it in front of the ear till no longer audible, and then place it on the mastoid process. If the sound be then heard, while a "negative" result has been obtained from the original experiment, the deafness is due to a lesion in the sound-conducting apparatus. On the other hand, a "positive" result by the first method, coupled with a difference in favour of aërial conduction when the test is applied in the reversed order, points to disorder of the labyrinth. Further reference will be made to Rinne's test in the chapter on the Diagnosis of the Diseases of the Internal Ear.

Gruber's Modification.—Gruber* has suggested the following modification of Rinne's test. After the sound of a vibrating tuning-fork held in front of the meatus has ceased to be heard, the forefinger of the other hand is placed in the opening, and the handle of the fork brought into contact with it. The sound will again be perceived, and will continue for some little time. The explanation, as given by Gruber, is that by closure of the meatus a column of air is formed therein, and strengthens the sound, which again becomes audible. It is also possible that the altered conditions of tension and pressure in the middle and internal ear may contribute towards the result, and also that those sonorous vibrations which were previously lost by dispersion are more effectively conducted to the cranial bones and the sentient apparatus. The test is applied as above described, and the surgeon inquires whether the sound is again heard, and notes the duration of the sensation. Gruber thinks that in cases of unilateral deafness, this modification will be found to be an improvement upon Rinne's method.

---

* *Monatsschrift für Ohrenheilkunde*, XIX. S. 33.

Gellé's Method.—Gellé* has proposed a method for distinguishing between labyrinthine and middle-ear affections. He places a vibrating tuning-fork in contact with the skull, and then condenses the air in the external meatus. Under normal conditions there is a decided diminution in the intensity of the sound; but if there be any obstacle to conduction—*e.g.*, anchylosis of the stapes—no alteration is perceived. On the other hand, if there be disease of the labyrinth and free movement of the stapes, the sound will be diminished with each condensation of the air, and the patient will complain of noises in the ears and especially of giddiness. The air is condensed by means of an india-rubber bag with an attached tube, the end of which is passed into the meatus. The tube is furnished with a manometer for regulating the pressure. Politzer states that Gellé's test is of little value, for in the majority of cases of middle-ear disease with moderate deafness, the sound of the tuning-fork is diminished in intensity while the air is condensed. On the other hand, in affections of the labyrinth, with a high degree of deafness, the sound may remain unaltered. It must be admitted that Gellé's test oftens agrees with the result of Rinne's experiments.

A watch having a somewhat weak tick is the most suitable for testing bone conduction; it may be applied either to the temple, to the malar bone, or to the mastoid process, the meatus on the side tested being closed with the finger. At first, the watch should be lightly, and afterwards firmly, pressed against the skull. If the result in one place prove to be negative, others should be tried before deciding that the auditory nerve cannot be thus affected. Moreover, in using the watch, it must be remembered that temporary loss of bone conduction may be caused by disorder of secretion and alterations of tension in the sound-conducting apparatus, and that restoration may sometimes be speedily effected by the injection of air. If, after several trials, the ticks be not heard, some impairment of perceptive power may be inferred to exist, and the acoumeter should then be used. A negative result indicates the existence of grave lesion of the sentient apparatus. On the other hand, if the watch be heard by a partially deaf person, the labyrinth may be regarded as free from any such lesion.

---

* *Tribune Médicale*, 1881, Oct. 23.

It must also be borne in mind that, as age advances, vibrations produced by instruments in contact with the cranial bones are less distinctly heard; in persons over fifty years of age it not infrequently happens that while the tick of a watch held opposite the ear is clearly perceived, bone conduction is either defective or altogether absent. In such cases the symptom has not the same significance as it possesses in younger subjects. Bezold states that bone conduction *per se* is not reduced in old age, but sinks proportionately with the lessening of the hearing distance.

CHAPTER V.

EXAMINATION OF THE NOSE, PHARYNX, AND EUSTACHIAN TUBES.

Frequent Dependence of Diseases of Middle Ear upon Morbid Processes in Pharynx and Nares—Importance of Examining these Parts and Eustachian Tube—Requisites for Anterior Rhinoscopy—Parts Visible—Examination of Mouth, Fauces, and Lower Part of Pharynx—Parts Seen—Posterior Rhinoscopy—Parts brought into View—Pharyngeal Openings of the Eustachian Tubes—Digital Examination of the Naso-Pharynx—Structures Distinguishable—Examination of the Eustachian Tubes—Tests of their Permeability—Valsalva's Method—Politzer's Method—The Author's Bag for Injecting Air—Description of Details—Distension of Cheeks—Modifications suggested by Lucae and Gruber—Use of Auscultation Tube—Precautions in Employing Politzer's Method—Occasional Unpleasant Symptoms—Effect Produced by Politzer's Method—The Eustachian Catheter, Forms and Description of the Instrument—Length, Gauge, and Curve of the Catheter—Author's Plan for Uniformity of Measurements—Vulcanite and Silver Catheters—Bag for Injecting Air—Employment of the Auscultation Tube—Introduction of the Eustachian Catheter—Modes of Overcoming Difficulties—Use of Air-Bag—Other Methods of Introducing Catheter—Plans Recommended by Frank and Gruber—Indications that the Catheter is in Proper Position—Injection of Air—Obstacles to the Introduction of the Eustachian Catheter—Methods of Dealing with them—Emphysema sometimes produced—Sounds produced during Injection of Air—Causes of Absence of Sounds—Action of Stream of Compressed Air upon the Eustachian Tube and Tympanum—Removal of Exudation—Improvement of Hearing-Power—Action in Cases of Perforation of the Membrane—Comparative Value of the Various Methods of Inflating the Tympanum—Passage of Bougies along the Eustachian Tube.

DISEASES of the middle ear are often due to extension of morbid processes from the pharynx and nares, and once set up are liable to be much influenced by the course of the original disorder. Inflammation of the naso-pharyngeal mucous membrane is a potent and common cause of acute and chronic catarrhs of the tympanum, and in treating cases of these disorders, remedies are generally required for the condition of the throat and nose. The necessity for examining these parts is therefore obvious. The Eustachian tube discharges an important function in connection with the middle ear, and it likewise furnishes a channel through which remedies can be applied to that part. The condition of the tympanum is greatly influenced by that of the tube, and hence careful examination of the latter structure is indispensable for purposes of diagnosis.

Examination of the Nasal Passages.—The nasal passages admit of examination from the front (anterior rhinoscopy) and from the pharynx (posterior rhinoscopy). The requisites for anterior rhinoscopy are a good light, either natural or artificial, a concave reflector with head-band, and specula of various forms. A double-bladed speculum is the most convenient instrument (Figs. 35 and 36), and with its aid in favourable cases it is possible to inspect a large portion of the nasal passages. A fenestrated speculum, recommended by some surgeons, fails to press back the hairs out of the line of vision. Thudichum's speculum is usually made with too strong a spring; this defect is easily corrected. The parts which can be brought into view are the septum and the anterior extremities of the inferior and middle turbinate bodies, the lower borders of which can be traced backwards for some distance. When the patient's head is inclined forwards, the floor of the nares and the inferior meatus are exposed, and by bending the head in the opposite direction, the middle turbinate bone and sometimes the roof of the nose can be seen. When the parts are much swollen, the space between the turbinate bones and the septum may be reduced to a mere

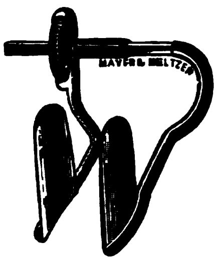


FIG. 35.
MUNCASTER'S NASAL SPECULUM.

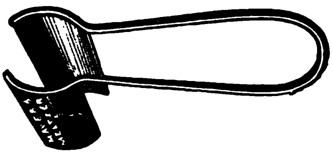


FIG. 36.
THUDICHUM'S NASAL SPECULUM.

chink, and in such cases it is necessary to press back the swollen tissue by means of a probe or small spatula. The application for a few minutes of a 2 to 5 per cent. solution of cocaine will cause the swelling to diminish.

The width of the nasal passages varies considerably in different cases; under favourable circumstances, and with the aid of a suitable speculum, some portion of the naso-pharynx can be seen from the anterior nares. Zaufal's nose-specula consist of cylindrical silver tubes, 3–7mm. in diameter, and 10 to 12½cm. in length, and having a funnel-shaped anterior extremity. Through these specula remedies may be applied to the posterior wall of the pharynx and the mouths of the Eustachian tubes, but they are very seldom required, and their introduction is apt to cause pain and some amount of hæmorrhage, while the area exposed to view is very limited.

The Posterior Nares.—The examination of the posterior nares is accomplished by means of a small laryngeal mirror (the same that is used for the larynx), and a mirror for reflecting the light into the throat. But before examining the naso-pharynx and posterior nares, it is well to notice the condition of the mouth and fauces and lower part of the pharynx.

The Pharynx.—The pharynx can be examined either by direct light, *i.e.*, by turning the patient's face towards a window, or by placing him with his back to the light and using a concave reflector. The latter is always necessary whenever artificial light is employed. The tongue is kept against the floor of the mouth by means of a depressor or the handle of a laryngeal mirror. In order to gain as complete a view as possible of the back of the pharynx, the patient should be directed to take a full inspiration or to pronounce the letter A (as "ah.") The parts that come into view are the concave under-surface of the velum, the uvula, the anterior and posterior pillars of the fauces, with the tonsil between them, on each side, and a portion of the posterior wall of the pharynx. Various alterations, more or less intimately connected with the condition of the tympanum, are often found in one or other of these parts. Enlargement of the tonsils is very common in children; adenoid growths from the naso-pharynx sometimes come into view, while granular pharyngitis is often present in cases of catarrhal inflammation of the middle ear. Absence of disease in the lower part of the pharynx does not justify the conclusion that the naso-pharynx is also in a normal state. The state of the teeth should be carefully noticed; severe otalgia is sometimes due to dental caries. The condition of the tonsils is a point of special importance; if these organs are enlarged in an upward direction, they are apt to keep the soft palate in a state of tension and to obstruct the action of the muscles connected with the Eustachian tube. In some patients it is difficult to depress the tongue sufficiently to allow the pharynx to be seen. Either retching is provoked immediately the spatula touches the surface, or the tongue bulges up against the hard palate. In some of these cases it will be found that the handle of the laryngeal mirror, used as a depressor, will meet with far less resistance, and will accomplish all that is necessary; but should this method fail, a view can generally be obtained by spraying the tongue and soft palate with a 2 to 5 per cent. solution of cocaine before an attempt is made to depress the tongue.

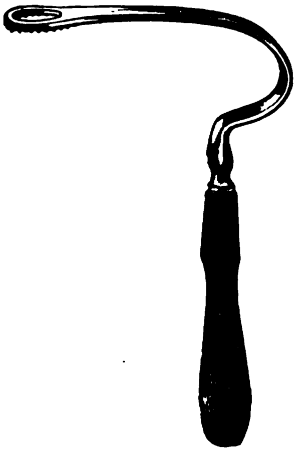


FIG. 37.

FRAENKEL'S TONGUE-DEPRESSOR.

Posterior Rhinoscopy.—Posterior rhinoscopy is effected in the following manner. The patient is placed in the ordinary position for laryngoscopy, but his head should be somewhat higher than that of the surgeon, and inclined slightly forwards. He is then told to open his mouth as widely as possible, and continue to breathe naturally. A mirror of small size is passed below, and partly behind the soft palate, and as far back as possible into the pharynx. In some cases, a better view is obtained if the handle of the mirror is slightly curved to fit the floor of the mouth.

Some form of tongue-depressor is occasionally necessary, and the shape of that devised by Fraenkel (Fig. 37) is the most convenient; but in some patients the tongue can be kept out of the way with the handle of the mirror. Although the shape of Fraenkel's tongue-depressor is convenient, the fenestration and transverse grooves are not only unnecessary, but are, moreover, liable to retain impurities. The author uses a tongue-depressor (Fig. 38) which has been made for him by Messrs. Mayer & Meltzer, of the same shape as Fraenkel's, but without the perforation and grooves. In passing the mirror backwards care must be taken to avoid touching the palate, base of tongue, or back of pharynx, otherwise the patient will scarcely be able to prevent retching. When it has reached the naso-pharynx, the mirror should be so held that its surface looks upwards and forwards. In some cases a better view can be obtained with a Michel's mirror (Fig. 39), which is fitted with a movable reflecting surface, than with an ordinary laryngeal mirror. When the soft palate and posterior wall of the pharynx are separated by only a narrow space, it may be necessary to hold the former forward by means of a palate-hook. Some patients allow this

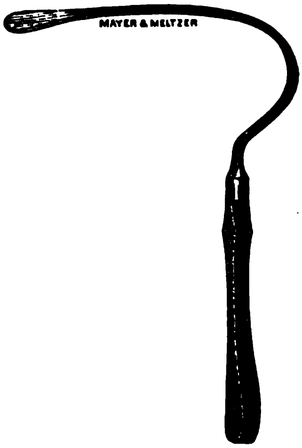


FIG. 38.

TONGUE-DEPRESSOR USED BY AUTHOR.

to be done without the previous use of a local anæsthetic; but, in many cases, a satisfactory view cannot be obtained until a

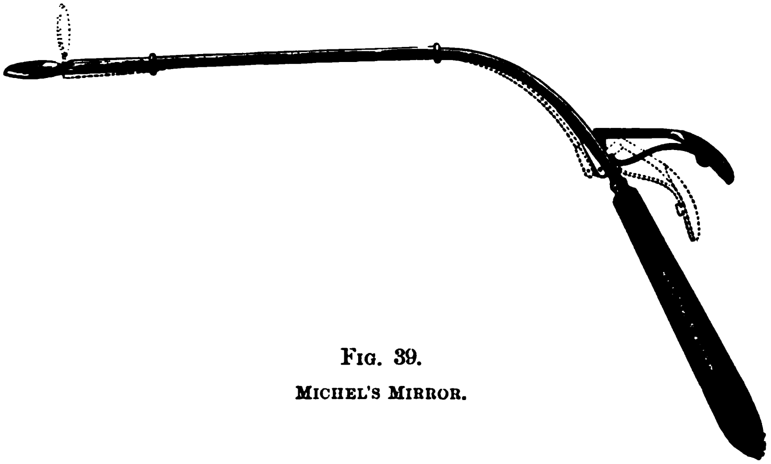


Fig. 39.

Michel's Mirror.

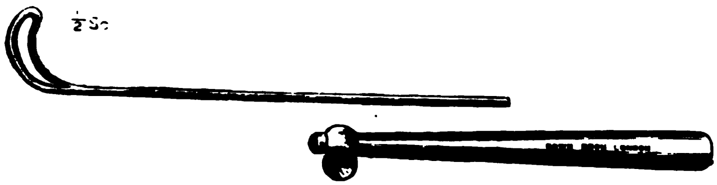


Fig. 40.

Palate Tractor used by the Author.

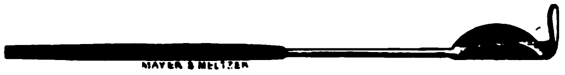


Fig. 41.

Voltolini's Palate Tractor.

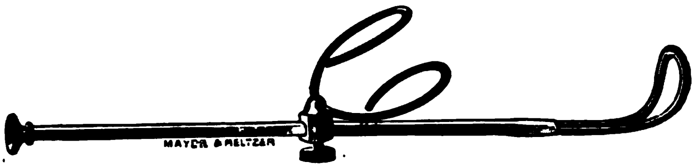


Fig. 42.

White's Self-retaining Palate Tractor.

2 to 5 per cent. solution of cocaine has been applied to the posterior surface of the soft palate by means of a brush fixed to

a handle with a short rectangular curve, or a piece of absorbent cotton-wool fixed to a holder bent in a similar manner.

The palate tractor which the author prefers is a loop of stout wire curved upwards at the end (Fig. 40). It is lighter than Voltolini's (Fig. 41), and serves very well the purpose for which it is intended.

When the throat is irritable, the tonsils large, and the space narrow between the soft palate and posterior wall of the pharynx, it is sometimes difficult or even impossible to obtain a good view of the naso-pharynx and posterior part of the nostrils. In some cases a better view is obtained when the patient expires slowly through the nostrils.

When the pharynx is irritable, in order to lessen the sensitiveness of the parts, a few minutes before the examination is made, a 2 to 5 per cent. solution of cocaine may be applied by means of a brush or spray producer to the velum, pharynx, and fauces.

Parts seen in Posterior Rhinoscopy.—The parts brought into view in posterior rhinoscopy are the elliptical *choanæ*, with the septum between them, the extremities of the turbinate bodies, the Eustachian orifice, and Rosenmüller's fossa on each side, the pharyngeal tonsil, and the upper surface of the palate. It is necessary to turn the mirror in various directions and to place it at different angles, in order to gain successive views of the various structures, only a portion of which are visible at the same time. In favourable cases (*i.e.*, when the palate is at some distance from the wall of the pharynx), by slight movements of the mirror, the vault of the naso-pharynx, the entire circumference of the posterior nares, and the posterior border of the hard palate may be brought into view. Within the choanæ are seen the *turbinated bodies* on each side, the middle one being the largest and the most conspicuous; it is usually bluish-red or greyish-blue in colour. Above it is the superior meatus, at the upper part of which the *superior turbinated body* can sometimes be made out. The portion visible is about as large as a pea, and has a yellowish tint. The middle meatus, below the middle turbinate, exhibits at its lower part the posterior extremity of the *inferior turbinated body*, which resembles in appearance an over-ripe plum. It is often only partially visible, its lower half being concealed by the palate; but sometimes it is enlarged to about the size of a raspberry, in which case its posterior extremity is in close proximity to the anterior lip of the Eustachian orifice. In some cases, the middle turbinate body impinges upon the septum and extends downwards almost to the floor of the nares, and touches the lower turbinate. The choanæ are about 1 inch high and ½ inch across; they are separated from each other by a thin vertical median septal membrane, prolonged backwards from the posterior edge of the vomer. Seen in the mirror, the septum appears as a sharply-defined ridge, of a pink colour, and narrower in the middle than at either extremity. It must be remembered that the nasal septum not infrequently deviates to one side. In young subjects, the upper and back part of the pharynx, from side to side, presents a large mass of lymphoid tissue, constituting the *pharyngeal tonsil*. This structure is not distinctly circumscribed; it occupies the space behind and between the Eustachian tubes on each side, and extends to the roof of the cavity as far as the choanæ (Macalister). Its tissue resembles that of the faucial tonsils; in adult subjects, it is often unrecognizable. In the middle of the naso-pharyngeal vault, the mucous membrane sometimes presents an irregular, flask-like pit, the *bursa pharyngea*, "whose opening is usually narrow and directed downwards and forwards, its wider fundus pointing upwards towards the basicranial foramen. It is a pouch of mucous membrane which occupies the site of the continuation upwards of the pharyngeal tube, pinched off by the in-growth of the para-chordal cartilages, and thereby separated from the pituitary body above." According to some authorities, the existence of this structure is due to pathological changes in the pharyngeal tonsil.

The Pharyngeal Openings of the Eustachian Tubes and the adjacent parts can be seen on careful examination with an ordinary laryngeal mirror. The position of the parts seen is of course changed; the cartilaginous swelling which forms the posterior lip of the orifice appears in front in the mirror, while the anterior lip is seen behind it, or farther from the eye. The long diameter of the opening, when it can be seen in the mirror, is directed from above downwards and forwards. The depression, called Rosenmüller's fossa, which is situated behind the posterior lip, appears in front of it in the mirror, and is somewhat darker in colour than the swelling which it bounds. This fossa can be best seen when the patient's head is slightly turned to the opposite side. The opening itself is in the form of a rounded triangle; the mucous membrane is lighter in colour than that of the adjacent wall of the pharynx. The posterior lip of the opening is yellowish or yellowish-red in colour. The morbid changes in the pharyngeal orifice to be looked for in diseases of the middle ear are congestion and swelling of the lips and adjacent parts, profuse catarrhal secretion; the presence of adenoid growths, ulceration and contractions, and in the posterior part of the nostrils a polypus or enlargement of the posterior extremity of a turbinated body. In children the roof of the pharynx is a frequent seat of adenoid growths, which, as will be shown in a subsequent chapter, are often associated with diseases of the ear.

Digital examination of the naso-pharynx enables the surgeon to ascertain the size and character of morbid growths existing in that cavity. It is performed by passing the forefinger behind the soft palate. If the right hand be used the surgeon stands on that side of the patient, but if the left, on the opposite side. The surgeon's finger should be protected to prevent it from being bitten by the patient, and for this purpose the author recommends a piece of india-rubber tubing, shown at Fig. 43, which has been drawn upside down in order to exhibit the piece removed from its right surface as the hand is held in Fig. 44. The guard should be about three inches in length and not less than one-eighth of an inch in thickness, with the lower half of the anterior half-inch cut away, and a V-shaped piece also removed from the right side to within half an inch of its anterior extremity, to allow the tubing to be pulled over the index finger until its front edge is behind the joint between the proximal and middle phalanges. By thus covering the first phalanx, the metacarpo-phalangeal joint and the head of the metacarpal bone, the parts usually bitten, are protected, whilst the two front joints of the finger are left free. The patient should be seated, and his head steadied by the surgeon's hand.

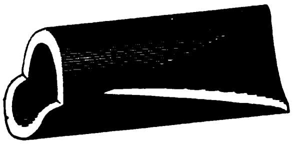

½ nat. size.

FIG. 43.

THE AUTHOR'S FINGER-GUARD.

Care must be taken not to press the uvula backwards, because it is difficult to get the finger behind the soft palate when it is closely applied to the posterior wall of the pharynx, and efforts at retching are very liable to be caused. The patient's head may be moved in various directions in order to facilitate the examination of the various parts, but this is usually unnecessary. If the finger cannot be easily passed into the naso-pharynx, its tip should be placed behind the lower part of the posterior pillar of the fauces on the side on which the surgeon is standing, and slipped upwards in the space between it and the posterior wall of the pharynx. By this means it will easily pass behind the soft palate. The structures which can be distinguished by the finger are the roof of the pharynx, the mouth of the Eustachian tube on each side, the projecting posterior lip and Rosenmüller's fossa behind it; the posterior border of the nasal septum, the boundaries of the posterior nares, the extremities of the middle and inferior turbinate bones, and the upper surface of the velum.

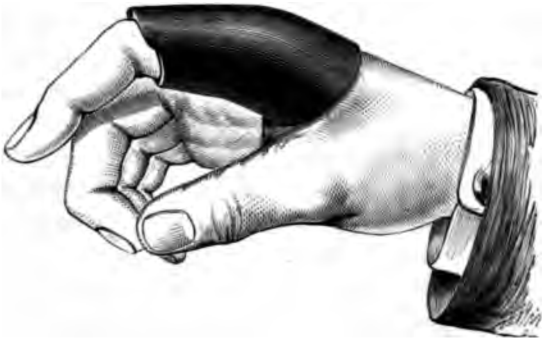


FIG. 44.

THE AUTHOR'S FINGER-GUARD IN POSITION.

The utmost gentleness should always be used when examining this region.

EXAMINATION OF THE EUSTACHIAN TUBES.

The permeability of the Eustachian tubes is the condition upon which the discharge of their functions depends, and it may be tested in three ways—(1) Valsalva's method of inflating the middle ear; (2) Politzer's method; (3) the employment of catheters, through which air is forced into the tubes.

(1.) **Valsalva's Method** of forcing air into the tympanum is as follows:—The patient takes a deep inspiration, and then makes a forcible attempt at expiration through the nose with the mouth shut and the nostrils firmly compressed with the fingers. The air is thus forced upwards from the thorax, and being unable to escape through the mouth or nose, some of it passes through the pharyngeal openings of the Eustachian tubes, and thence to the tympana. The patient is conscious of a sensation of pressure or fulness in these parts, which, if the tubes are healthy, subsides when saliva is swallowed, and the mouths of the tubes thus opened; but if the tubes are obstructed, the feeling of fulness may remain for several minutes. It is best for the surgeon to compress the nostrils himself, because by suddenly relaxing the pressure he can judge of the amount of expiratory force which is being used. Patients often appear to be blowing hard through the nostrils, when in reality they are either not doing so at all, or else only to a slight degree, their energy being entirely or principally expended in merely distending their cheeks. If the membrana tympani be examined with a speculum as the air is thus forced into the cavity, it will be seen to bulge out slightly, especially at its posterior and superior segment. The cone of light is altered in size, and may entirely disappear. On using the auscultation tube two sounds are heard; one of these is due to friction of the air against the walls of the Eustachian tube, while the other, a short sound, is produced by the air striking against the membrana tympani. Care must be taken not to mistake the sound produced by the contraction of the pharyngeal muscles for that caused by the entrance of air into the tympanum.

When the mucous membrane of the tubes is much swollen, the expiratory pressure will be insufficient to force air into the tympanum. When the membrane is perforated, the method often succeeds, and may be employed to force secretions from the middle ear; the passage of air through the perforation causes a hissing sound. Permeability of the tubes may be inferred when positive results are obtained; if no air can be forced into the tympanum, some obstacle may be presumed to exist either in the tube or some other part of the middle ear.

In many cases Valsalva's method can be very easily accomplished, and with decided improvement in the hearing-power as a result. Too frequent repetition is, however, liable to cause congestion of the head, with a similar condition of the tympanum, and a permanent alteration in the natural curves of the membrane, consequent upon its having become relaxed from being too often stretched by forcible expiration. Patients should therefore be instructed as to the number of times that the method is to be practised, whenever it is prescribed as a part of treatment.

The author does not agree with Roosa,* where he says, whilst speaking of Valsalva's method of inflation, "and as a means of diagnosis it is, in most cases, vastly inferior to the use of the catheter or Politzer's method." On the contrary, it supplies information as to the degree of obstruction to the entrance of air into the Eustachian tubes, which cannot be obtained either by the use of a catheter or Politzer's inflation; moreover, in some cases it renders unnecessary the employment of either of these methods of injecting air for testing permeability.

When the Eustachian tubes are in a normal condition, or when their lining membrane is not much swollen, air can be forced through them by Valsalva's method; but when this cannot be done, it is evident that they are obstructed to more than a slight degree. If the patient begins by expiring gently, and gradually increases the force, the degree of pressure required to send air through the tubes can be ascertained; and at the same time, by placing an auscultation tube in each ear and noticing whether both tubes open simultaneously, knowledge will be gained as to whether an equal amount of obstruction exists in both tubes, and if not, which is the more affected.

Neither a slight degree nor the comparative amount of obstruction can be estimated by means of a catheter or Politzer's inflation, unless one tube is blocked to a considerable extent; and, therefore, Valsalva's method of inflation possesses advantages which cannot be claimed for either of the other methods.

(2.) **Politzer's Method** of forcing air through the Eustachian tubes, and of thus rendering them permeable, was suggested by some experiments he made as to the fluctuations in the air-pressure in the tympanum. During the act of swallowing, the naso-pharnyx is closed below by the soft palate, which comes into contact with the posterior wall; and if air be at the same time injected through one nostril and the other be tightly closed, the air in the nares and naso-pharynx will be more or less condensed and forced through the Eustachian tubes into the middle ear on each side. The mouths of the tubes are opened by the act of swallowing, which thereby facilitates the passage of the air. The instrument best adapted for practising this method is an india-rubber bag, having a capacity of ten ounces and fitted with Gardiner Brown's nozzle. As shown in the accompanying woodcut (Fig. 45), this nozzle is rectangular in shape, and its extremity tapers to a comparatively fine point, so that it can be introduced into the nostril of even a young child. Being made of soft rubber, it becomes distended while the air is passing through it, and thus completely plugs the nostril in which it has been placed. The length of the tubing between the bag and its nozzle—about sixteen inches—enables the surgeon to move his arm freely whilst compressing the bag, and prevents the possibility of injury being caused by any movement of the surgeon's hand being communicated to the patient's nose. When this method of inflation is used, the patient should always be seated, because giddiness is liable to be produced by the sudden increase of pressure of air in the tympanum.

---

* *Treatise on the Diseases of the Ear*, 6th edition, p. 77.

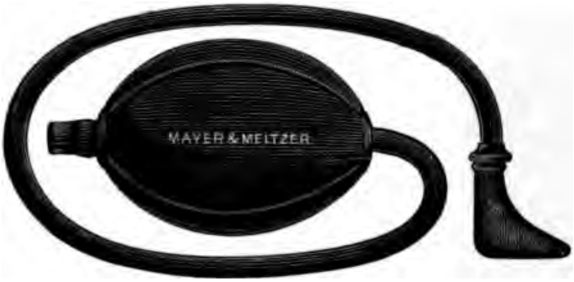


FIG. 45.

THE AUTHOR'S 10-OZ. AIR-BAG FOR POLITZER'S INFLATION FITTED WITH GARDINER BROWN'S NOZZLE.

The bag is used in the following manner:—The surgeon stands on the right side of the patient (who is seated in a chair), and introduces the nozzle into one nostril, with its point directed along the inferior meatus; he then compresses the ala of the other nostril with the left thumb or a finger, so as to prevent the escape of air. The patient is then told to distend his cheeks with air; and when this is done, the surgeon forcibly compresses the bag with his right hand. When the air in the naso-pharynx is thus compressed and driven into both tympana, a feeling of resistance to the complete emptying of the bag is usually experienced. If this method fail, the patient may be directed to take a mouthful of water, to be swallowed at the bidding of the surgeon, who compresses the air-bag when the larynx is seen to rise. Success is indicated, as in the previous method, by the resistance experienced; and, to some extent, by a dull gurgling sound, due to the vibration of the soft palate previously in contact with the posterior wall. The surgeon should stand at the patient's side, because children and even adults do not always keep the mouth firmly closed, and consequently water may be forced out of it, and over the surgeon's coat, unless he keeps out of the way. With adult patients water is often unnecessary, the act of swallowing being sufficient. In treating young children all special instructions may be omitted, inasmuch as in these cases the capacity of the naso-pharynx is small, the Eustachian tubes are short, and their mouths are easily rendered patent. During crying the soft palate comes into contact with the posterior wall of the pharynx, and thus facilitates the passage of air into the tubes.

Modifications of Politzer's Method.—Other modifications of the method of closing the naso-pharynx have been suggested by various surgeons. Lucae* suggests that instead of swallowing water, the patient should be instructed to pronounce the sound "ah," and thus to cause the soft palate to be applied to the posterior wall. Gruber† recommends that the patient should be directed to pronounce the syllable "huck," with emphasis on the last letter. The tongue is thus forced backwards, and its posterior part comes into contact with the soft palate. In employing these modifications of Politzer's method, the surgeon compresses the bag as the patient utters the sound, with which he should be made quite familiar before the operation is begun.

As compared with swallowing, both distension of the cheeks and phonation present several advantages; they are more easily accomplished, and take up less time. Moreover, the pressure can be maintained for a longer period than is the case when a mouthful of water is swallowed. This latter plan, however, sometimes answers when the other methods prove ineffectual. In some cases, both distension of the cheeks and the utterance of a syllable fail to close the pharynx, and the soft palate is forced downwards by the condensed air before any effect has been produced upon the Eustachian tubes. In addition to this, it must be remembered that the result of swallowing, so far as the tubes are concerned, is different from that of phonation; a degree of pressure which suffices to open the tubes in Politzer's method may fail to produce any effect when the other plans are adopted.

---

* *Virchow's Archiv*, 1875, Bd. 64.

† *Lehrbuch der Ohrenheilkunde.* S. 222.

In the case of children, Hinton used frequently to inflate the tympana by blowing through a piece of india-rubber tubing, one end of which was inserted in his mouth and the other in one of the child's nostrils.

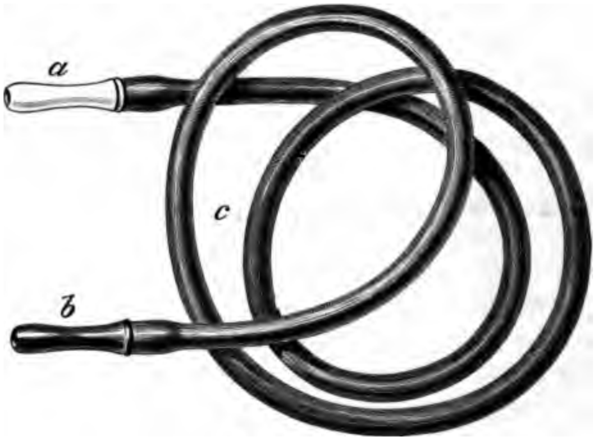


FIG. 46.

AUSCULTATION TUBE.

The Auscultation Tube, sometimes called Diagnostic Tube, enables the surgeon to ascertain whether the injected air passes along the Eustachian tube. This instrument (Fig. 46) consists of a piece of india-rubber tubing about thirty inches long, furnished at each end with an ear-piece made of a hollow piece of ivory or vulcanite, one to be introduced into the meatus of the patient and the other into that of the surgeon. Care must be taken that the auscultation tube hangs freely, and is not compressed or bent at a sharp angle, either of which conditions may prevent the passage of sound. The ear-pieces should be of such a size that they fit comfortably into the meatus, and it is well to have one made of ivory (*a*), and the other of vulcanite (*b*), to enable the surgeon to distinguish them, and keep one for his own use. When this instrument is used, a gurgling sound will, of course, be heard as the water is swallowed; but, besides this, the practised ear will distinguish the friction-sound of the air passing through the tube, and the short sound caused by the movement of the membrane. When perforation exists, a hissing noise may sometimes be heard with the unaided ear.

Precautions while Employing Politzer's Method.—When the parts are in a normal condition, the air will pass into both tympanic cavities with an equal degree of force; but the existence of an obstacle on one side will render the effect more marked in the pervious tube. In such cases, and likewise in those of unequal occlusion of both ears, the meatus on the normal or on the less affected side, as the case may be, should be stopped by the finger while the air is being injected. A similar precaution must be taken in cases of unilateral perforation of the membrane; the meatus must be firmly closed on that side, so as to prevent the air from escaping. Inclination of the head to one side facilitates the entrance of air into the opposite tube; thus, if it be wished to act especially upon the left tube, the head should be inclined towards the right shoulder.

The amount of force to be employed in injecting the air varies in different cases, and must be regulated by the degree of resistance that has to be overcome. Violent injections are likely to cause unpleasant sensations; rupture of the membrana tympani has ensued in some cases.

Occasional Unpleasant Effects of Politzer's Method.—It has been stated above that the injection of air, as in Politzer's method, sometimes causes unpleasant symptoms. Headache and giddiness are occasional results; attacks of faintness and a feeling of sinking are less common. Noises in the ears are more frequently produced, and this symptom may last for some time. If much force be used, air may pass into the œsophagus, and cause nausea and various uncomfortable sensations in the stomach. These will rapidly pass off if the patient takes a few deep inspirations. Rupture of the membrana tympani is a very rare accident; the injection of air through a catheter, as well as by Valsalva's method, has also been known to produce it. In cases in which the accident has occurred, there has generally been some morbid condition of the membrane; such as atrophy or a cicatrix, or calcareous deposits. Under such circumstances, a slight rupture of the membrane is not likely to be attended with any untoward results; on the contrary, some improvement in hearing-power is generally experienced. When a morbid condition of the membrane is known to exist, rupture may be prevented by closing the meatus with the finger when the air is injected. In cases of this kind, however, it is better to inject air through a catheter, by means of which the pressure can be easily regulated. Politzer states that a force of three to four atmospheres is required to rupture a normal tympanic membrane; the pressure employed when his method is practised rarely exceeds half an atmosphere.

General Results of Politzer's Method.—The effect produced by injecting air by Politzer's method varies with the nature of the lesion. When there is marked deafness as a consequence of swelling and accumulation of secretion in the tympanum and abnormal tension of the membrane, the improvement after the injection is often very considerable. But when structural changes have taken place, and the development of bands of connective tissue and adhesions interferes with the movements of the ossicles and membrane, and also when the nervous structures are the seat of the lesion, little, if any, improvement can be expected from the use of Politzer's method.

The indications for the employment of Politzer's method, and a comparison of its advantages as compared with those of Valsalva's plan, and of the use of the Eustachian catheter, will be given at the end of this chapter.

(3.) **The Eustachian Catheter: Forms and Description.**—The third method of injecting air into the Eustachian tube involves the use of a catheter, which is passed through the inferior meatus of the nose into the pharyngeal opening. The Eustachian catheter is made either of silver or vulcanite, and should not exceed 11½cm. in length. It presents a curve near its thinner extremity, and its outer end is funnel-shaped, for the reception of the nozzle of an india-rubber air-bag. The curved portion, or beak, is about 2½cm. in length, and forms an angle of about 135° with the straight portion. (Fig. 47.) As the dimensions of the inferior meatus vary according to the size of the superior maxillary bone, the presence or absence of spurs, deviations of the septum, etc., the length, gauge, and curve of the catheter are not only important in themselves, but should also be capable of being expressed in such a manner as would prevent mistakes, and enable the practitioner to describe in exact terms the instrument required.

The catheter suitable for the majority of patients corresponds with the size No. 9 of the French urethral catheter gauge; this will be found to convey the air in sufficient volume into the middle ear. A larger instrument presents no advantages, and is likely to cause discomfort in its passage through the nostrils. At the present time the gauge is described by numbers 1, 2, 3, etc.; but even these do not represent any particular standard, and instruments supposed to be similar often vary in their gauge and curve as well as in their length.

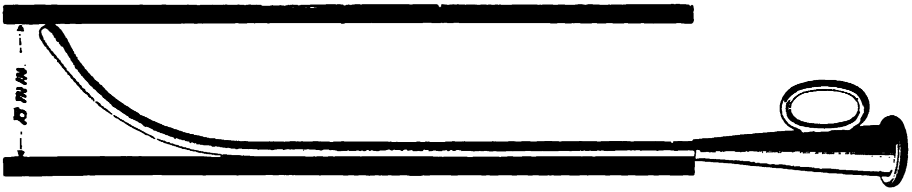


Fig. 47.

Illustration of Catheter with a Curve of 18mm.

In order to prevent difficulties in description and to ensure uniformity of construction, the author proposes (1) that the length of a catheter should be measured by a straight line drawn from its larger extremity along the lower surface of the stem—the beak pointing upwards—to a line at a right angle thereto, and touching the extremity of the beak. If the former line measure 11½cm., it will be found that when the instrument is in the position suitable for injection of air, the anterior portion of its stem does not project more than 3cm. beyond the floor of the nostril, and that consequently the nozzle of the air-bag can be easily and firmly held in contact with the catheter by the thumb and forefinger of the left hand whilst air is being injected. For the introduction of the shortened form of catheter, now in general use in this country, the profession is indebted to the late Mr. G. F. Hodgson, of Brighton. In or about the year 1876, finding the old-fashioned catheter, which was about seven inches in length, unnecessarily long, he had a piece cut out of one of his instruments, and the ends joined with a collar of metal, so that the catheter was reduced to four and a-half inches in length. The shortened instrument answered so well that Mr. Hodgson had all new ones made to its length. The objection to the longer form of catheter is that it cannot be held properly in position (see Fig. 52, page 131), while, at the same time, the nozzle of the air-bag is securely kept in the funnel-shaped orifice during the injection of air. (2) The second proposition is that the gauge of Eustachian catheters shall correspond with that of the French catheter gauge, which is well known and graduated on a definite scale. (3) Supposing that the curve of the beak corresponds with an angle of 135°, its length shall be expressed in millimetres, indicating the distance between two parallel lines. The lower line should be drawn along the lower surface of the catheter (placed with its beak directed upwards); the upper line should touch the extremity of the beak. Another line drawn perpendicularly to the parallel lines may be termed the "beak-line"; its length will serve to represent the length of the beak.

As already mentioned, a catheter corresponding with No. 9 French gauge, with a beak-line of 18mm., is suitable for most adult male cases; but its beak is sometimes found to be too long to allow the catheter to be turned outwards in the naso-pharynx. When this difficulty is experienced a catheter with a beak-line of 16mm. can generally be passed. It is well that the practitioner should be provided with four catheters—viz., two of No. 9 gauge, with beak-lines of 18 and 16mm. respectively; and two of No. 7 gauge, with similar beak-lines. In exceptional cases catheters with beak-lines of 14 and 20mm. respectively may possibly be required. A catheter of No. 5 gauge is seldom necessary. A general practitioner can do good work even with three instruments—viz., one of No. 9 gauge, with 18mm. beak-line; No. 7, with 16mm., and No. 7, with 14mm. beak-line. By such a nomenclature as that suggested, a standard can be formed which is intelligible to all. As the gauge must be measured by the slightly enlarged extremity of the beak, the actual gauge of the stem will be somewhat less than the number specified.

If it be found that, owing to the direction of the beak of the catheter, the air does not strike the lumen of the Eustachian tube, the difficulty may be remedied by moving the outer end of the stem of the instrument either away from or towards the mesial line. The air can be injected into the tube, if the end of the beak just touches the orifice.

At the outer end of the catheter a ring is attached to that portion of the circumference which corresponds with the curve; the ring serves to indicate the position of the beak when the catheter is introduced. Special catheters should be kept for syphilitic cases, because the disease may be conveyed from one patient to another by means of these instruments. For some years past, the author has used an instrument (Fig. 48) for these cases which has a collar of copper about three-eighths of an inch in width fitted to the funnel-shaped portion. This method of marking has the advantage of being cleanly and indestructible, and readily distinguishes the catheter from those used for ordinary cases. A catheter should be kept very clean, and disinfected after use, because catarrh as well as syphilis can be communicated by means of this instrument if proper precautions are neglected. The author now always uses silver catheters, because their diameter is less than that of a vulcanite catheter with the same bore, and they are as well tolerated by patients as those made of the latter substance. Vulcanite catheters are cheaper than silver ones, and by some surgeons are considered more easy to pass when an obstruction exists, on account of their greater elasticity. This supposed advantage, however, the author has not experienced.

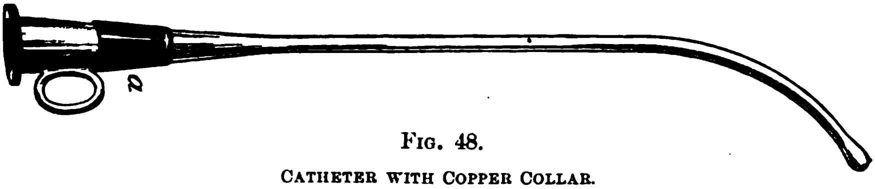


FIG. 48.

CATHETER WITH COPPER COLLAR.

Vulcanite catheters possess one advantage as compared with silver instruments: they are not affected by remedies injected through them. They are, however, more difficult to cleanse, and this drawback is one of considerable importance in view of the possibility of the syphilitic virus and catarrh being conveyed by their means. After a vulcanite catheter has been used, it should be kept in a solution of perchloride of mercury (1–1000) for some hours, and then washed in warm water. Vulcanite catheters can be bent in any direction; to soften them, they should be dipped in hot water or held over a lamp, and when the requisite curve has been given, it can be rendered permanent by di instrument in cold water. Metallic catheters are mo disinfected by being placed in a 20 per cent. solution acid and afterwards boiled.

Bags for Injecting Air.—For injecting air catheter, Politzer's india-rubber bag may be employed author prefers a bag (Fig. 49) fitted at one end wit (*a*), and at the other with a piece of tubing about fift in length, which has attached to its other end a vulcan (*e*) made to fit accurately the funnel-shaped end of the

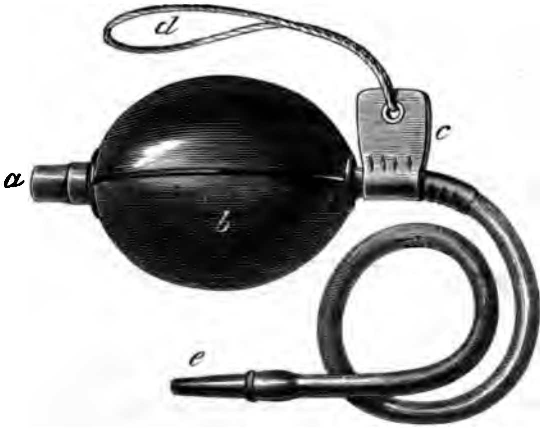


Fig. 49.

India-rubber Bag for Injecting Air through a Cathete

Immediately in front of the bag is a piece of leather (*c*) which is passed a loop of silk (*d*) for suspending the button on the surgeon's coat, and it will be found best it to one of the upper buttons, because when so suspen is less probability of its dragging on the catheter tha fastened to one of the lower buttons. It is important bag should be suspended by its anterior part; because arrangement, if the bag be dropped, its weight falls suspender and not upon the catheter, whereas if th attached behind, any sudden movement will be commun the catheter. If Politzer's air-bag is employed, a piece rubber tubing, several inches in length, should always b connect its nozzle with the catheter; this addition prev being caused to the patient and possible injury to th membrane by the movement of the bag being communicated to the catheter when the air is injected.

Introduction of the Eustachian Catheter.—From statements made to the author by several medical men, the impression seems to prevail that the introduction of an Eustachian catheter is a difficult and very painful procedure; and, furthermore, that if attendance upon an aural case is to be continued, and the patient's confidence retained, it is essential that a catheter should not be used. An old friend of the author's, an exceptionally good practitioner, told him a short time ago that he had once tried to pass an Eustachian catheter, but had not since dared to make another attempt, for the man on whom he was operating uttered a groan as the instrument was introduced, and then fell on the floor in a fainting condition. The surgeon referred to was himself suffering from a slight defect of hearing, and the passage of a catheter had been proposed by the author. As a result of his experience, he now passes a catheter dexterously not only on his patients, but also upon himself. Without doubt, Eustachian catheters are frequently passed in an improper manner. At their first visit, patients often appear to doubt the correctness of the assurance that the use of the catheter is a painless procedure, and object to the little operation because of their previous unpleasant experiences.

The mistakes usually made are:—

1. Not holding the catheter sufficiently lightly.
2. Using an instrument either too large or having too long a curve.
3. Using force during the introduction.

A catheter cannot be held too lightly, and should always be made to glide through the nostril, care being taken to keep it in the inferior meatus.

The patient should always be *seated*, with his head resting against the back of the chair, or a rest if one is provided, and the surgeon should always *stand* on the patient's right side. The chair Fig. 50 is very convenient for this purpose: the head-rest (*e*) made by Messrs. Ash is easily adjusted to any position by the handle (*d*), and can be slipped either forwards or backwards along the rod (*c*). Its height is regulated by the rod (*a*), which is secured by the handle (*b*).

The movable table (*f*) attached to the arm carries any instrument which may be required, and the clips fixed to it securely hold the stem of a glass, when fluid injections are required, and prevent the vessel being overturned. Before attempting to pass an Eustachian catheter, the auscultation tube should be placed in the patient's and the surgeon's ear, and the air-bag should be suspended

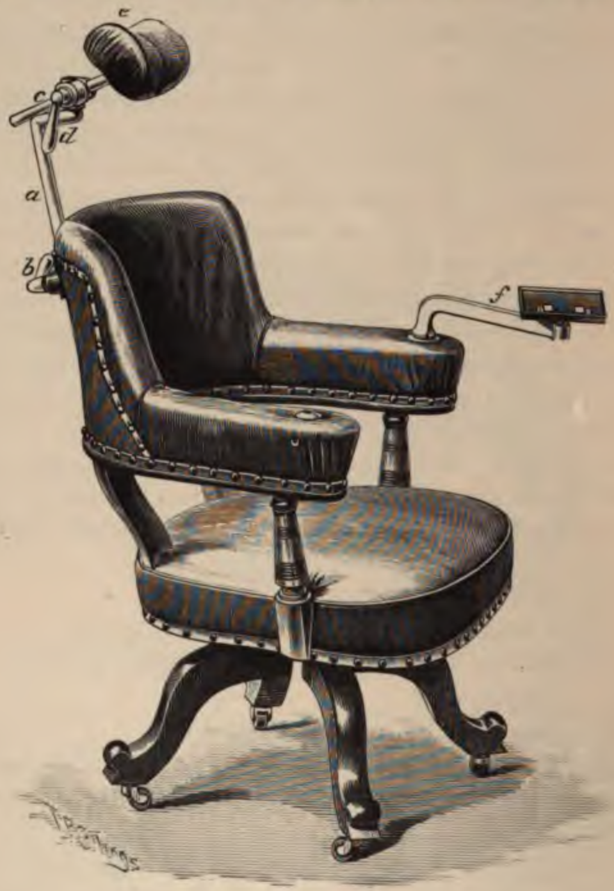


Fig. 50.
The Author's Revolving Chair.

from a button on the surgeon's coat. The tip of the nose should then be gently raised by the left thumb, whilst the hand is steadied by the fingers being rested on the patient's forehead. The catheter selected should be held very lightly in a vertical position by its larger end, between the thumb and the first and second fingers of the right hand, with the beak uppermost, and directed towards the nostril into which it is about to be inserted. Care must be taken to keep the beak against the floor of the nose, otherwise it is apt to get into the middle meatus. To ensure this, the right hand should be raised as the catheter passes into the nostril, until finally the instrument is in a horizontal position. As soon as the beak is felt to touch the posterior wall of the naso-pharynx, it should be withdrawn half an inch, and turned outwards and slightly upwards, when it will be found to be in the orifice of the Eustachian tube. The precise distance which the catheter must be withdrawn necessarily depends upon the antero-posterior dimensions of the naso-pharynx, but about half an inch is usually sufficient. The above and the following detailed methods for finding the orifice of the Eustachian tube are of service only to those who are unaccustomed to pass a catheter. After a little practice the beak of the instrument can be turned directly into the orifice of the Eustachian tube, without previous contact with the walls of the naso-pharynx. If the catheter is drawn backwards by muscular contraction, when the beak is turned outwards in the naso-pharynx, it is an indication that it is in the fossa of Rosenmüller. As soon as the beak of the catheter is in the Eustachian orifice, the third and fourth fingers of the left hand should be placed one on each side of the patient's nose, the palm of the hand being downwards and forwards (Fig. 52), and the outer end of the instrument grasped between the thumb and index finger. The nozzle of the air-bag should now be introduced into the funnel-shaped orifice, and the thumb and index finger of the left hand slipped forward to hold it in that position, the second finger supporting the catheter whilst this is being done. Air is then injected into the tympanum by compressing the air-bag.

The advantage of the method above described for holding the catheter in position, whilst air or fluid is being injected into the middle ear, is that the relative position of the surgeon's hand and the catheter with the patient's face remains unaltered if the patient moves his head; whereas, if the catheter is merely steadied by the surgeon resting his fingers against the patient's nose or forehead, it is pressed into the tissues, and causes pain if the patient moves his head, because by so doing he alters the relative position of his face, and the surgeon's hand holding the catheter. When the beak of the catheter is thought to be in the orifice of the Eustachian tube, and the nozzle of the air-bag has been inserted into the funnel-shaped end, the bag should be compressed at first only gently, whilst the sound produced by the air is listened to by means of the auscultation tube, in order to ascertain whether the position of the catheter is correct. As soon as that is found to be the case, air may be more forcibly injected into the middle ear. If an india-rubber bag, unprovided with a valve for refilling, is used for injecting air, its nozzle must be withdrawn from the catheter before the pressure of the hand is removed to enable it to refill. Unless this is done, secretion from the naso-pharynx will be drawn into the catheter as the air-bag expands, and may block up its orifice. Compression of the bag should, therefore, be kept up until it is removed from the catheter. When distended with air, the bag is replaced and again compressed, and these manipulations may be repeated four or five times, or more often if necessary. In the withdrawal of the catheter, the beak should be turned downwards and kept close to the floor

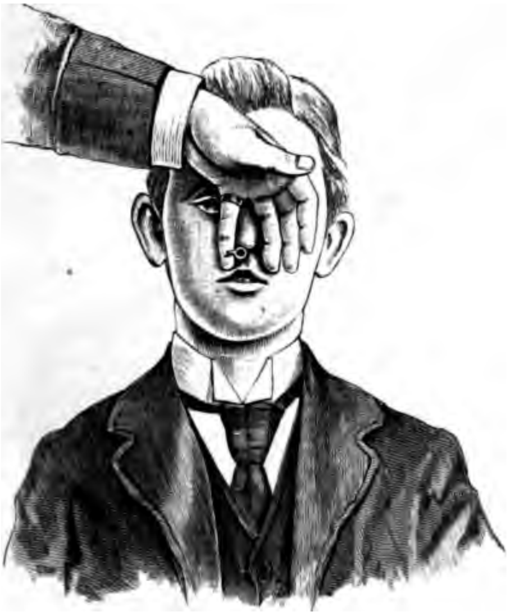


FIG. 52.

SHOWING POSITION OF THE THIRD AND FOURTH FINGERS OF THE LEFT HAND WHILST A CATHETER IS BEING USED.

of the nares. To prevent the tickling which the passage of the catheter is apt to produce, a 2 per cent. solution of cocaine may be injected into the nostrils. Finding that the metal cocaine spray producer in general use imparted a metallic taste to the solution, the author requested Messrs. Mayer & Meltzer to make a fine spray producer in vulcanite, and after a little difficulty they supplied him with the instrument shown at Fig. 53, which works very well.

There are several other methods of introducing the Eustachian catheter; it will be sufficient to describe two of them.

Frank's Method is convenient, inasmuch as the posterior border of the nasal septum is used as a guide in its performance. The catheter is introduced as before, with the point in contact with the floor of the nares. When the posterior pharyngeal wall is reached, the instrument is turned so that its extremity, as shown by the position of the ring, points towards the *opposite* side; it is then withdrawn until the beak is arrested by the nasal septum. The instrument is then steadied between the thumb and forefinger of the left hand, and turned upon its long axis through half a circle, with the apex downwards. At the completion of this manipulation, the point of the catheter will be directed horizontally towards the pharyngeal opening of the Eustachian tube.

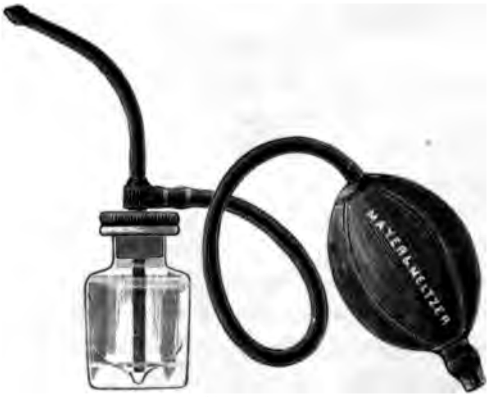


FIG. 53.

VULCANITE COCAINE SPRAY PRODUCER.

Gruber's Method. –In the method recommended by Gruber, the catheter is passed along the floor of the nares, as above described, until the posterior wall of the pharynx is reached. It is then withdrawn until it touches the posterior border of the hard palate. Care must be taken not to draw the catheter back into the nostril; to prevent its going too far, its outer end must be somewhat raised. The pharyngeal opening of the tube is about one-fifth of an inch behind the border of the hard palate; to find it, the catheter must be pushed slightly backwards, and then turned through a quarter or three-eighths of a circle on its long axis, with its apex directed outwards. The point will then impinge upon the pharyngeal opening, and will pass into it if the outer extremity be moved slightly downwards and towards the septum.

Indications that the Catheter is in Proper Position.—When the apex of the catheter is lodged in the opening of the Eustachian tube, a sense of resistance will be experienced when an attempt is made to turn it upwards. Its position will not be altered when the patient swallows, and if air be injected, the sound of its passing along the tube will be heard with the aid of the auscultation tube. If the beak of the catheter be lodged in Rosenmüller's fossa, there will be little, if any, resistance when it is turned upwards; if it be embraced by a fold of mucous membrane, the stem will move freely when the patient swallows or speaks.

Obstacles and Methods of Overcoming them.—Obstacles to the introduction of the Eustachian catheter are not infrequently met with; and when difficulty is experienced, the nose should be carefully examined with the aid of reflected light. Great sensitiveness of the mucous membrane, swelling of the parts, especially of the inferior turbinated body, deviations of the septum, cartilaginous and bony spurs, polypi and strictures from ulceration, may render the introduction of the catheter very difficult, or even impossible. As, therefore, the dimensions of the nostrils may vary very much, there is no rule for the position of the catheter during its passage. It often passes best if the beak is directed horizontally outwards beneath the inferior turbinated body, as soon as it is well within the nostril, and turned a little down again as it goes through the choana.

Sometimes the instrument can be passed by holding it lightly, and gently turning it from side to side whilst it is pushed backward; and occasionally rotation of the catheter in the naso-pharynx, through three-quarters of a circle, will effect the desired end. If a large-sized catheter will not pass, a smaller one should be tried, or one with a shorter curve. A catheter should always be passed with the greatest gentleness, and in many instances it is best to allow it to find its own way. If the difficulty is caused by the swollen condition of the soft tissues, a 2 per cent. solution of cocaine will generally remove the obstruction.

When it has been found impossible to introduce the catheter through one side, an attempt may be made to reach the mouth of the tube from the opposite side. The catheter used for this purpose should have a long and strongly curved beak. It is passed into the nares in the manner already described, and when the posterior wall of the naso-pharynx is reached, it should be withdrawn half an inch, and the beak turned towards the ear which is to be catheterised.

In nervous and very sensitive people, attempts to pass the Eustachian catheter may be frustrated by attacks of retching or vomiting, and uncontrollable movements of swallowing. When these are very violent, it may be necessary to remove the catheter; they will sometimes subside if the patient takes deep inspirations through the nose. Convulsive attacks of coughing and continuous sneezing sometimes necessitate withdrawal of the catheter; but these difficulties can generally be removed by spraying into the nostrils a 2 per cent. solution of cocaine a few minutes before the instrument is introduced.

Emphysema sometimes Caused.—In a few cases the injection of air through the Eustachian catheter has caused emphysema beneath the mucous membrane, extending to parts at a considerable distance from the throat. This accident may occur if the membrane be injured by the point of the catheter, and also in cases of ulceration. Under either of these circumstances, air may find its way into the sub-mucous tissue, and pass under the mucous membrane of the soft palate and pharynx to the orifice of the larynx, and to the subcutaneous connective tissue of the cheek and side of the neck. It has also been known to pass into the thorax between the ribs and the costal pleura. In two cases in which a powerful air-pump was used to force air into the tube, the fatal result which ensued was probably due to emphysema of the glottis. If the catheter be carefully introduced, and the air-bag be employed, emphysema is very unlikely to occur; and should a small quantity of air pass into the sub-mucous tissue, it will become absorbed in the course of a few days.

The symptoms depend upon the amount and seat of the emphysema. On inspecting the mouth and throat, the mucous membrane of the soft palate and uvula is seen to be swollen and distended, so that these parts are considerably enlarged; the posterior wall of the pharynx is bulged out, and the lips of the orifice of the Eustachian tube are much larger than natural. The cheek on the affected side is puffed out, and the eyelids are swollen. The swelling may be so great as to be easily discernible; if slight, it may be detected on digital pressure. The subjective symptoms vary; a feeling of tickling and irritation in the pharynx is usually complained of, and if the larynx be involved in the œdema, difficulty of breathing will become very prominent. In the majority of the recorded cases, the emphysema subsided within a few days under the use of cold applications and gargles. Prominent emphysematous portions of mucous membrane may be incised with the point of a bistoury.

The accident above described invariably results from unnecessary, and therefore unjustifiable, force being used to introduce the catheter, and air being forced through it when the resistance shows that the catheter is not in its proper position. The sound conveyed by the auscultation tube should clearly demonstrate that the air is not passing into the tympanum.

The Risk of Conveying Syphilis by means of the Eustachian catheter, and the plans to be adopted to preclude infection, have already been discussed (see page 125).

Sounds Produced during Injection of Air.—The injection of air into the Eustachian tube produces certain sounds which can be heard through the auscultation tube. With a normal condition of the parts the air entering the tympanum causes a blowing sound, which has been compared to that heard when rain falls upon the leaves of a tree. This sound is due to the friction of the air upon the walls of the tube and of the tympanic cavity. Its character is influenced by alterations in the width of the tube and in the size of the catheter. With a narrow tube and also with small catheters the sound becomes shrill and high; under opposite conditions its pitch is changed. The condition of the membrana tympani considerably modifies the character of the sound; when the membrane is tense the sound is distinct and harsh, and may resemble that which is heard in cases of perforation, inasmuch as it appears to originate close to the ear of the listener. When the membrane is relaxed the sound is less distinct and soft.

Râles, or rattling sounds of various kinds, are often heard when the tympanum or Eustachian tube contains excess of secretion. Fine bubbling râles generally originate in the tympanum, whereas more distinct and interrupted sounds of this character are produced in the pharyngeal half of the tube. When the membrana tympani is perforated, the character of the sound is modified by the size of the opening, by the amount of secretion in the middle ear, and by the degree of permeability of the tube. A whistling or hissing sound is characteristic of a perforation, and when excess of secretion co-exists, bubbling râles will be superadded. These sounds will appear to originate close to the ear of the surgeon.

Sounds sometimes Absent.—It may happen that no sounds are produced when air is injected. The most frequent cause of this negative result is a foreign body in the catheter or a kink in the auscultation tube. The feeling of resistance to the compression of the air-bag in the former case instantly reveals the cause to a practised hand. The absence of sound, however, may be due to impermeability of the Eustachian tube from adhesion of its walls, or to obstruction caused by foreign bodies. In other cases the sound suddenly ceases, and then again becomes audible. This peculiarity may be caused by changes in the position of the Eustachian catheter, or by folds of mucous membrane acting as valves. It must not be forgotten that râles may be produced in Rosenmüller's fossa when the beak of the catheter is lodged therein. The stream of air forms bubbles in the mucus of the fossa, and also throws into vibration the posterior lip of the tube. These sounds are heard as if produced at a distance from the ear. If the catheter be drawn forwards and its beak placed within the lips of the tube, a marked difference will be perceived in the character of the sound, and the entrance of air into the tympanum will be experienced by the patient.

Action of Compressed Air on Eustachian Tube and Middle Ear.—Before considering the relative advantages of the three methods by which air may be injected into the tympanum, it seems desirable to point out the manner in which compressed air acts upon the Eustachian tube and the structures contained in the middle ear.

When a current of air passes from the naso-pharynx into the tympanum, certain effects are produced upon the Eustachian tube, the membrana tympani, and the structures covering the fenestra rotunda and the fenestra ovalis. The air distends the Eustachian tube and removes from it any excess of secretion, a portion of which is driven into the pharynx and the remainder into the tympanic cavity. The pressure of the air upon the walls of the tube tends to reduce any existing hyperæmia, and thus temporarily enlarges its calibre. The effect of the current upon the membrana tympani is very marked, and can easily be seen with the aid of the speculum and measured with the ear manometer. The injected air forces the membrane outwards, causing it to bulge into the external meatus. In this movement it carries with it the handle of the malleus, and this in turn, though to a lesser extent, draws the incus and stapes in an outward direction. If, as often happens, the membrane be too much curved inwards and tightly stretched, and the movements of the ossicles be much impeded, the forcible introduction of a current of air will restore the membrane to its normal position and re-establish its capacity for vibration. The marked improvement in hearing which often results from the employment of one of the methods already described is due to the increased mobility of the membrane and chain of ossicles.

There are other structures in the middle ear which can be acted upon by a current of air through the Eustachian tube. A common result of inflammatory processes is the formation of bands of connective tissue which considerably interfere with the movements of the membrane and ossicles, and these bands are stretched to some extent by the force of the air. The tendon of the tensor tympani can be similarly affected. The two fenestræ are also acted upon, and undue rigidity caused by inflammatory deposit may be lessened or overcome. Abnormal tension in the labyrinth will be reduced by lessening the pressure of the stapes upon the fenestra ovalis.

Removal of exudation is another result of inflation of the tympanum. The extent to which such removal can be effected depends upon the consistency of the fluid and the state of the tympanum and adjacent parts, for if inflammation is present it may be undesirable to inject air into the middle ear. When the exudation is fluid and consists only of serum, it can usually be got rid of in the course of one or two days by frequent injections of air, even when it has been present for several weeks; but when it is inspissated, either in consequence of the admixture of mucus or on account of its long existence, the membrane may have to be incised in order to effect its removal. The escape of the exudation when the membrane is intact will be facilitated if, during the injection, the head is inclined forwards and to the opposite side. But even if little or no exudation escape, the inflation may effect considerable improvement in the hearing-power by forcing the tympanic membrane outwards, and increasing the mobility of the ossicles, as above described. It will act beneficially in another manner, viz., by re-establishing the normal pressure of air in the tympanic cavity. As Politzer has pointed out, closure of the Eustachian tube in catarrhal and inflammatory affections of the middle ear causes rarefaction of the air in that cavity. As a result of the reduction of pressure, an exudation of fluid takes place from the blood-vessels and lymphatics, a condition which has been described as *hydrops ex vacuo.* The injection of air restores the normal pressure, reduces the hyperæmia of the mucous membrane, and thus promotes the absorption of the exudation. The object of frequent injections of air is not only to prevent the vacuum re-forming, but also to keep up intratympanic pressure, and thus assist in the absorption of the fluid. This subject will be referred to again later on when dealing with exudation into the tympanum.

When perforation exists, the effect of a current of air forced through the Eustachian tube is to propel any exudation into the external meatus, and thus to relieve the tube and the tympanic cavity. The membrane will be forced outwards, and will carry with it the chain of ossicles, so that the normal tension of the labyrinth will be to some extent restored. There is no risk of forcing secretion into the mastoid cells; experiments * have proved that when perforation of the membrane exists, morbid contents of the tympanum will be driven into the meatus by a current of air through the Eustachian tube.

Comparative Value of the Various Methods.—A discussion of their comparative value will complete this account of the various methods of inflating the middle ear.

(1) **Valsalva's method** has the advantage of simplicity and ease of execution; but where there is great resistance, the force of the

---

* Michel, *Archiv für Ohrenheilkunde*, Bd. XI.

current of air is likely to prove insufficient. As a means of diagnosis, a positive result implies that mechanical obstruction is either very slight or entirely absent; but if the result be negative, some obstacle may be inferred to exist. Also, when the tubes are unequally affected, it enables the relative amount of obstruction to be ascertained. It must always be borne in mind that inflation of the middle ear by this method, depending as it does upon forced expiratory efforts, produces hyperæmia of the cerebral vessels and venous congestion: it is, therefore, not unattended with danger when practised by persons the subjects of disordered conditions of the vessels in question. The mucous membrane of the tympanum likewise partakes in the hyperæmia, and too frequent repetition of the process is therefore likely to promote exudation.

When the membrane is perforated, Valsalva's method often proves very useful. Very little effort is required to force secretion from the tympanum into the external meatus. The patient should always be warned against too frequent repetition of the process; and if there be reason to suspect disease of the cerebral vessels, Valsalva's method should not be practised.

(2) **Politzer's method** of inflating the middle ear is of great value in all cases in which the use of the catheter is either impossible, or attended with great difficulties and drawbacks. Thus children, among whom catarrhal affections of the middle ear are very common, frequently will not allow a catheter to be passed, whereas they readily submit to Politzer's method. Also in nervous adults and in cases of malformation of the nares, the latter plan is usually practicable. It is likewise preferable in cases of inflammatory swelling of the nasal or pharyngeal mucous membrane, a condition likely to be made worse by the use of the catheter. As compared with Valsalva's method, Politzer's plan has the advantage of forcing air into the tympanum at a lower pressure, which can, however, be raised at the will of the surgeon. In many cases the method can be practised by the patient himself, after a few instructions. Lastly, the sudden rush of air into the tympanum is sometimes more efficacious than the weaker current which passes through the Eustachian catheter.

(3) **The use of the catheter** is indicated in cases in which the disease is confined to one side, and whenever it is desirable to

inject fluids into the middle ear. It is also useful when the pharyngeal orifice of the Eustachian tube is much swollen, and resists the action of the current in Politzer's method. It may also be tried whenever the latter plan produces disagreeable results, such as distension of the stomach and giddiness. Lastly, auscultation can be better practised when the catheter is employed, because the force and amount of the air injected can be regulated, and the passage of air gives rise to a more distinct sound. Hence the catheter is especially suited for purposes of diagnosis.

Passage of Bougies along the Eustachian Tube.—Reference must be made to another method, recommended by some authorities, of testing the permeability of the Eustachian tube, and of relieving or curing constrictions, due either to swelling of the mucous membrane or to growth of connective tissue in the sub-mucous layer. This plan consists in passing bougies along the tube with the aid of the catheter. As a matter of fact, however, the author never has recourse to this method of treatment; he doubts the efficacy of bougies thus used, and he is quite sure that they are capable of causing serious mischief. If the passage of a bougie be immediately followed by the restoration of some amount of patency to the tube, it is at least highly probable that the occlusion was due to a plug of inspissated mucus which would have been softened, and would have come away in a few days if a few drops of a weak alkaline solution had been injected through an Eustachian catheter. If the obstruction be due to swelling of the mucous membrane, it is difficult to suppose that any real benefit can result from the passage of a bougie, for the previous condition will be restored when the instrument is withdrawn. It is alleged that various medicaments can be conveniently applied with the aid of a bougie; but they can be used in solution with greater safety, and quite as efficiently, through the Eustachian catheter. The use of bougies, however, for purposes of diagnosis and treatment, is still advocated by several German authorities, and especially by Urbantschitsch.* A few American aurists regard bougies as indispensable in cases where obstruction of the Eustachian tube does not yield readily either to Politzer's method or to injections of air through the catheter. A brief description of the method of using the bougie will therefore be appended.

---

* *Lehrbuch der Ohrenheilkunde*, 3 Aufl. S. 24.

It must be remembered that the length of the Eustachian tube varies considerably in different cases (3·5–4·5cm.); the seat of a constriction cannot therefore be exactly ascertained. The cartilaginous portion measures about 2·5cm., and the osseous part rather less than half this length. The calibre at the isthmus is about 1½mm. According to Urbantschitsch,* a constriction is indicated if the smallest bougie (1⅓mm.) cannot be made to enter the osseous tube, or is passed with great difficulty. If the obstacle be at a distance of 16mm. from the pharyngeal orifice, the stricture is in the cartilaginous portion; if at from 22–30mm., it is in the isthmus, or very close to it; if at from 30–40mm., the obstacle is in the osseous portion. The possible existence of folds and angularities in the course of the tube must always be kept in mind. Urbantschitsch now recommends celluloid bougies as the most suitable; they are smooth and flexible, and are not affected by sublimate solution. Each extremity is rounded and slightly constricted below (*à boule*). These bougies are apt to become fragile after a time, and if minute transverse lines appear on the constricted portion the instrument should be discarded.

Preparation and Introduction of the Bougie.—A suitable catheter is selected (one having a long and decidedly curved beak is to be preferred), and the bougie is passed along it until the rounded head appears at the orifice. A small mark is then made on the bougie on a line with the funnel-shaped end of the catheter, and starting from this, a scale is constructed with marks at 5mm. apart. The catheter is introduced in the usual way, and when it is in its proper position, as proved by auscultation, the bougie is passed along it until the first mark coincides with the outer extremity of the catheter. The bougie is then pushed onwards with a rotatory movement, only very slight force being used to overcome any obstacle that may be encountered. If the attempt prove unsuccessful, the bougie should be withdrawn and a thinner one tried. Constriction very rarely occurs on the tympanic side of the isthmus; it is therefore generally sufficient to pass the bougie just beyond the latter spot. In order to act upon the isthmus itself, the head of the bougie should be slightly withdrawn, and allowed to remain in position for a few seconds, or even for a few minutes.

---

* *Archives of Otology*, vol. xii. p. 353.

The bougie should not be passed along the tube for more than 35mm. If this limit be exceeded, the ossicles or tympanic membrane may be damaged, the bougie getting between the malleus and the incus, and impinging on the membrane. Perforation has been thus caused, and in other cases sudden deafness has resulted, probably from dislocation of the ossicles.

That the bougie has been properly introduced into the tube is shown (1) by the manner in which the catheter is retained in its position, and (2) by the absence of any alteration during swallowing, inasmuch as the action of the muscles of the tube and pharynx produces little, if any, effect, owing to the manner in which the bougie is held. When the latter has been withdrawn, it ought to appear slightly curved, somewhat in the form of the letter S, in correspondence with the course of the tube. If, on the other hand, the bougie be sharply curved upwards or downwards, it has probably failed to pass through the tube. The passage of the bougie gives rise to a sensation of pricking in the region of the larynx, and extending in the direction of the tympanum. As the head of the bougie passes through the isthmus, the sensation in the tympanum becomes more marked, and is often referred to the membrane. Pain extending downwards, and increased by the act of swallowing, indicates that the bougie is not passing properly along the tube. Passage of the instrument through the isthmus is generally accompanied by crepitation, which can be heard through the auscultation tube. Any symptoms caused by the introduction of the bougie usually pass off soon after its withdrawal. Urbantschitsch, from whose work the above account has been derived, states that in a few of his cases the use of the instrument has relieved the symptoms of migraine, and of trigeminal and occipital neuralgia.

According to the authority just quoted, the use of the bougie is indispensable in many cases of chronic catarrh of the tympanum; it often proves effectual after the catheter has failed to relieve. It is not to be limited to cases of stricture of the Eustachian tube, or to those in which there is evidence of a diminution of calibre, which cannot be dealt with in any other way. On the other hand, its use is indicated for the removal of swelling of the walls of the tube—an almost constant accompaniment of chronic tympanic catarrh. Urbantschitsch claims, in addition, that the passage of the bougie not only dilates the tube, but acts reflexly on the auditory centres through the sensory nerves. He denies Politzer's assertion that the effects of such reflex action rapidly pass off.

In the last edition* of his work on "Diseases of the Ear," Politzer states that the results of mechanical dilatation of strictures of the Eustachian tube are not, on the whole, very favourable. In cases of constriction due to swelling, instead of the bougie, he sometimes uses a thin rubber capsule 4mm. long and 1½mm. wide, "which is fastened to the top of the catheter by a thread. After the insertion of the instrument into the tube, the capsule is inflated through repeated pressure of air into the catheter." The lateral pressure upon the vessels of the mucous membrane diminishes the amount of blood contained therein, and reduces the swelling.

For constrictions which do not yield to other methods of dilatation, and when an organic stricture is supposed to exist, Politzer considers that the introduction of a bougie into the Eustachian tube is advisable for the completion of the diagnosis, and as a method of treatment. He uses, as a general rule, bougies of silkworm gut, slightly club-shaped at the extremity. For severe constrictions he prefers the whalebone instruments recommended by Dr. Suarez di Mendoza. These are highly polished and rounded, and, in consequence of their greater resistance, pass more easily through the constricted portion. Each series contains eleven bougies, the ends of which vary in size up to 1mm. In order to provide for continuous dilatation of the Eustachian tube, Dr. di Mendoza has invented a catheter, which is divided into two parts lengthwise. "After the introduction of the bougie, one part of the catheter is first removed from the nose, then the bougie is lifted out by gentle lateral pressure of the now open second half, which is also removed. The projecting piece of the bougie is cut off close to the nostril, and remains twenty-four hours in the tube."

Politzer's opinion with regard to this method of treatment has been already stated. He admits that permanent improvement is very rare; that in many cases no dilatation is effected, and that aggravation of the local troubles is not unusual.

---

* Translation edited by Sir W. Dalby, p. 304.

CHAPTER VI.

METHODS OF TREATMENT.

Syringing the Ear—Method of Performing—Symptoms occasionally Caused—Application of Heat and Cold to the Ear—The local Abstraction of Blood—Massage—The Introduction of Medicated Solutions into the Meatus—The Insufflation of Remedies in the Form of Powders—The Air-Douche and Injections through the Eustachian Tube—The Injection of Vapours and Gases through the Eustachian Tube—Constitutional Treatment.

IN order to avoid repetition in subsequent chapters, it seems desirable to give an account of those methods of treatment which are applicable to many diseases of the ear, and are therefore frequently employed. These methods include (1) Syringing the auditory canal; (2) The application of heat and cold to the ear and adjacent parts; (3) The local abstraction of blood; (4) Massage; (5) The introduction of medicated solutions into the meatus; (6) The insufflation of powders; (7) The air-douche and injections through the Eustachian tubes; (8) Constitutional treatment.

(1) **Syringing the Ear.**—The syringe is often used for the removal of foreign bodies and of accumulated ceruminous and purulent secretion. The meatus should be thoroughly examined before having recourse to the syringe, for much injury may be done if there be nothing to remove or if perforation of the membrane exist. Syringes in common use are made of glass, metal, and vulcanite. Glass and vulcanite syringes are fragile, and apt to get out of order; a syringe made of brass is, on the whole, the best (Fig. 54); it should hold from three to four ounces. The ordinary instrument is too well known to require minute description; the ring *e*, Fig. 54, at the end of the piston, should admit the thumb comfortably; the cap of the cylinder has

rings, *d*, *d*, for the first and second fingers. The piston should be freely movable, while fitting closely into the cylinder. The nozzle, *a*, should be about an inch and a half long, and somewhat slender. If thick or very bulbous at the extremity, it takes up too much room in the meatus, and prevents the ready escape of the fluid after injection.

The profession is indebted to the late Mr. Gardiner Brown for devising a syringe with the nozzle attached by a bayonet-joint (*c*), and removable each time the syringe is filled. The advantages of this model are that the syringe is filled far more quickly, on account of the greater size of the aperture in the neck, *g*, and the entrance of air into the syringe is almost, if not entirely, prevented, as the suction is materially diminished by the freedom with which the water enters. For the removal of cerumen, it is best to direct the stream of water against the roof of the meatus, as the accumulation, unless in great quantity, is smaller there than along the floor. When a straight nozzle is used, the syringe comes into contact with the outer edge of the trough. To overcome this drawback, the author, some years ago, had a curved nozzle made (*b*), Fig. 54, and has since used a straight nozzle only in exceptional cases. Care should be taken to keep the syringe as

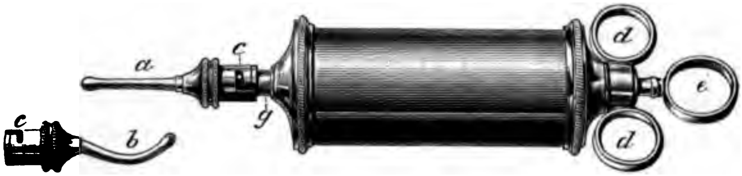


FIG. 54.

SYRINGE, WITH NOZZLES FITTED WITH BAYONET-JOINT.

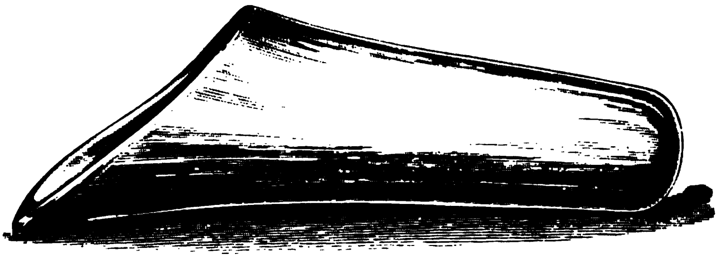


FIG. 55.

GARDINER BROWN'S EAR-TROUGH.

clean as possible. The fatty matter used to lubricate the piston may become decomposed owing to the development of fungi, which, if injected into the ear, might set up disease. The piston should often be placed in carbolic solution, and lubricated with carbolised vaseline. For a patient's own use—for removing purulent secretion—a bottle-shaped india-rubber syringe, holding six or eight ounces, and fitted with a nozzle having a very small bore, does very well. A glass syringe usually sucks in a large quantity of air, and is found unsatisfactory.

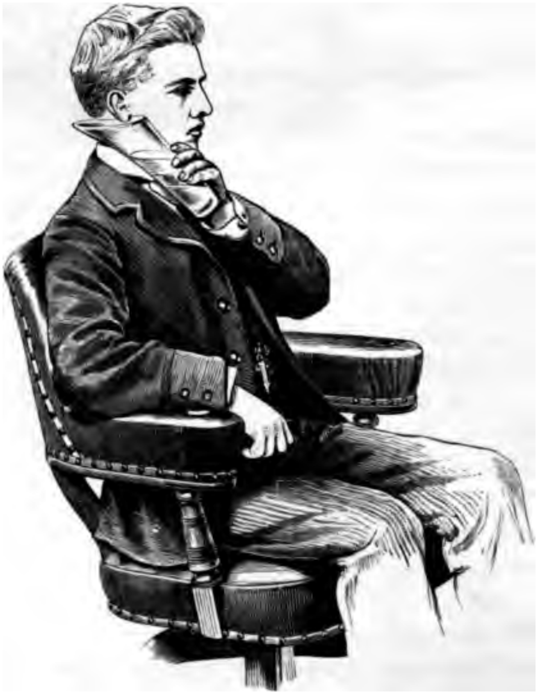


FIG. 56.

EAR-TROUGH IN USE.

To catch the fluid after injection, a bowl made of vulcanite, shaped to fit closely to the side of the neck below the ear, may be used; but the author much prefers the ear-trough (Fig. 55) devised by the late Mr. Gardiner Brown,* or its modification

---

* Gardiner Brown's ear-trough may be obtained from Down Bros., 21. St. Thomas' Street, S.E.

(Fig. 57) made by Messrs. Mayer & Meltzer. The patient should be directed to hold the trough with the hand of the opposite side to the ear which is being syringed, as shown in Fig. 56; by so doing the trough is kept more closely to the side of the head. The water used for injection should invariably be warm, the best temperature being between 100° and 105° Fahrenheit, as this allows for the slight loss of heat which occurs whilst the water is passing through and from the syringe, and leaves the water sufficiently warm to be comfortable to the patient. In cases of perforation, attended with purulent discharge, it is well to add either common salt or sulphate of sodium to the water ($\frac{3}{4}$ per cent.). Such solutions will prevent the precipitation of the albumins of the pus.

Method of Using the Syringe.—Syringing the ear should be effected in the following manner:—The patient should be so placed that the light falls directly upon the ear, and he should always be seated, because syringing the ear is liable to produce giddiness, and may even cause the patient, if standing, to fall. The patient should hold the bowl or trough in such a manner as to prevent the fluid from running down the neck and wetting the clothes. The syringe having been filled, it is well to turn the nozzle upwards and press upon the piston so as to force out any air which the cylinder may contain. With the left hand, the surgeon should then draw the auricle upwards, backwards, and outwards, so as to straighten the canal as much as possible. He should then place the nozzle of the syringe just

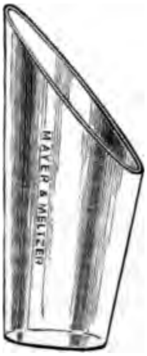


FIG. 57.

MAYER & MELTZER'S MODIFICATION OF GARDINER BROWN'S EAR-TROUGH.

within the meatus, and near its upper and posterior part, and before pressing the piston home, steady the syringe by resting its shoulder against the thumb of the hand which is holding the ear. By thus steadying the syringe, not only is greater power and accuracy obtained in directing the stream of water, but injury to the meatus is prevented should the patient suddenly move his head, because when thus held the head and syringe move together. It is well to direct the fluid against the wall of the canal, and not against the membrana tympani, and it is also advisable to begin with a *very gentle* current, and *gradually* to increase the force. In dealing with nervous patients, the water should be injected into the concha for a few seconds, as a preliminary procedure.

Symptoms occasionally Caused.—Syringing the ear, even when carefully performed, sometimes causes giddiness, nausea, and other unpleasant symptoms. These are mainly due to increased pressure upon the structures of the labyrinth, and are apt to be severe when perforations exist in the membrane, so that the fluid can act directly upon the fenestræ. If apertures likewise exist in the external wall of the labyrinth, the severity of the symptoms will be much increased. Besides giddiness and nausea, symptoms of meningitis have been known to supervene. Dr. Roosa* has reported a case in which severe syncope was caused by very gentle syringing of the ear. The patient, however, was liable to faint under the least excitement. Convulsive movements, and noises in the ears lasting for some time, have been noticed in a few cases. All these untoward symptoms are more likely to occur when cold water is employed. As a general rule, if proper care be taken, syringing is very well tolerated.

After syringing, the ear should be examined in order to see whether success has been achieved, and also to note the condition of the meatus. The canal should then be thoroughly dried and closed with a plug of cotton-wool. To ensure the removal of all fluid, the patient should bend his head to the side, and the meatus should be afterwards dried by pieces of absorbent cotton-wool introduced with aural forceps or twisted round a probe. To prevent the possibility of injuring the ear, the wool should be arranged so as to project about half an inch beyond the end of the instrument to which it is attached. Other special details with regard to syringing the ear, injections through the Eus-

* *Archives of Otology*, vol. ix. p. 16.

tachian tube, and the use of intra-tympanic syringes will be found in subsequent pages.

(2) **The Application of Heat and Cold to the Ear and Adjacent Parts.**—A douche of warm water to the meatus is of great service in cases of diffuse inflammation of that part and in acute and chronic catarrh. A siphon arrangement, with a piece of rubber tubing, a jug of warm water, and an ear-spout, will answer all requirements; but the Fayette Taylor* aural douche, recommended by Roosa, is still more convenient. This apparatus consists of an ear-piece, with two holes bored through it, one lying above the other. Fitted into these holes are two pieces of rubber tubing, one ascending and terminating in a funnel, which is dropped into the vessel containing the fluid as soon as the siphon action has been started, while the other passes down into the vessel which receives the fluid after use. At the inner end of the ear-piece, the division between the holes is cut back about one-eighth of an inch, so as to make the upper and lower channels communicate. To start the siphon action, a finger is placed over the inner end of the ear-piece, and the tube is filled with water; the funnel-end is then dropped into the jug. The ascending tube, just as it enters the ear-piece, is next compressed, so as to arrest the flow, the finger is removed from the end, and the ear-piece is inserted into the auditory canal. Pressure is then withdrawn from the tube, and the water immediately flows into and out of the meatus and down into the receiver. Thus a current of water is caused to flow steadily over the walls of the canal and the surface of the membrana tympani. In most cases the effect of the warm water is very grateful to the patient.

Warm poultices and hot fomentations are sometimes used in the treatment of external otitis, whether diffused or circumscribed. They relieve pain and tension, but they are liable to cause relaxation, softening, and ulceration of the deep part of the canal, and of the membrana tympani. Moreover, their prolonged use stimulates the development of granulations, especially in cases of abscess of the meatus. Poultices should not be used for the relief of deep-seated inflammation of the ear; they promote the development of profuse and tedious suppuration. A sponge dipped in hot water and wrung out, and frequently renewed, will answer the purpose of a poultice. Another simple method of applying warmth and moisture is to pour warm water into the affected ear and allow it to remain for a few minutes. This should be kept up for half an hour, or longer, and repeated every three or four hours.

---

* *Archives of Otology*, vol. viii. page 355. and Roosa's *Diseases of the Ear*, p. 129.

Cold may be applied to the ear in several ways, either to reduce the temperature of inflamed parts or to cause contraction of the blood-vessels and lessen the supply of blood. For acute inflammation of the external or middle ear, cold may be applied by means of folds of linen previously dipped in water at a temperature of 45° Fahr. and wrung out. A plug of cotton-wool should first be introduced into the meatus. To produce a decided effect, the linen must be re-dipped in the water every few minutes. For cases of severe inflammation, recourse may be had to Leiter's coil (Fig. 58) or an ice-bag, which latter should be applied over compresses of linen, varying in thickness according to the effect which it is desired to produce. To excite contraction of the carotid artery, Urbantschitsch* recommends Winternitz's india-rubber neck-bag, through which water is kept flowing. Pounded ice, wrapped in a handkerchief and applied to the front and sides of the neck, answers the same purpose. Cold thus applied for some minutes reduces the temperature of the external meatus. It must be borne in mind that the first effect of cold applications may be to increase the pain and other symptoms, though after a little

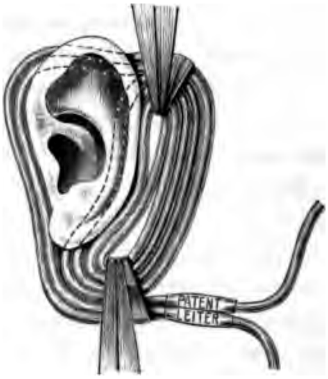


FIG. 58.

LEITER'S APPARATUS FOR APPLYING COLD TO THE MASTOID PROCESS. (*Politzer.*)

---

* *Lehrbuch der Ohrenheilkunde*, Dritte Aufl., S. 48.

while, relief is generally obtained. In delicate subjects, warm applications are often more soothing. The good effects of cold applications are especially marked in cases of acute inflammation of the mastoid process.

(3) **The Local Abstraction of Blood.**—In the treatment of acute inflammatory processes involving various portions of the organ of hearing, local blood-letting is often very useful. Leeches are generally employed for this purpose; their application frequently results in the rapid diminution or the removal of pain. Their use is especially indicated in the early stages of an acute attack; in chronic disorders they are seldom beneficial. When the external meatus and the tympanic membrane are the seat of inflammation, the leeches should be applied to the immediate neighbourhood of the tragus; but when the tympanum and the mastoid process are involved, the surface immediately behind and below the auricle should be selected. One or two leeches will be sufficient for children; in adult cases, from three to six may be necessary.

Before using the leeches a plug of cotton-wool should be placed in the meatus, and the selected part should be thoroughly cleansed. It is well to dry the leeches by rolling them gently in a clean linen cloth. In the absence of a proper glass, a test-tube may be used to hold the leech, and in order to ensure its biting at the right place, a piece of paper or thin card should be notched at one edge, and slipped beneath the end of the test-tube, the notch occupying the position at which the leech is intended to become attached. The test-tube should be partially filled with wool, in order to keep the leech at the open end. Another method, which often proves efficacious, is to grasp the body of the leech gently in a dry cloth, and thus to direct its head. By slightly withdrawing the leech as its head touches the skin, it will often fix itself to the spot and begin to draw blood. A piece of paper or card, notched as before mentioned, will prevent the leech from attaching itself away from the selected place.

Should the leech refuse to bite, a drop or two of milk may be smeared over the part. Gently scarifying or pricking the surface is another plan which often proves successful.

A leech usually drops off spontaneously in from fifteen to thirty minutes; it withdraws, on an average, about one drachm and a half of blood. A pinch of salt, placed over its mouth, will cause it to let go its hold. When the leeches have fallen off it is generally desirable to promote the discharge of blood by warm applications; but great caution is necessary in the case of children, and means for checking the bleeding should always be at hand. Compression, when necessary, may be easily made by means of a little cotton-wool pressed into the bite with a knitting needle or probe, and covered with a compress and bandage. Wool saturated with *collodium flexile* will often arrest the flow.* The application of a saturated solution of alum will sometimes check obstinate hæmorrhage from leech-bites; and if this fail, recourse may be had to finely-powdered gallic acid, tannic acid, or resin. Styptics, however, should not be used unless absolutely necessary, for they are apt to prevent the leech-bites from healing. After the bleeding has ceased, the spots should be covered with *collodium flexile*, or with thin sticking-plaster. This precaution is especially necessary in cases attended with purulent discharge from the ear.

Rest should be very strictly enjoined after the application of leeches; all movements of the head should be avoided as far as possible. If benefit be obtained, but prove to be evanescent, a second and even a third application may be desirable.

In the absence of leeches, Heurteloup's instrument (artificial leech) may be employed, but only in cases unaccompanied with tenderness of the parts.

(4) **Massage** in various forms has been recommended for the relief of several affections of the ear. The mechanical effect upon the lymphatic channels promotes absorption; and besides this, it is claimed that the acoustic centres can be indirectly affected, and that the reflex actions thus evoked may produce beneficial effects.

It would appear that massage† was first recommended in 1879 for the relief of acute middle ear catarrh. A few years later, Zaufal adopted the method, and described the way in which it should be employed. His directions are as follows:—The patient, with the upper part of his chest bare, sits on a low stool and turns his head slightly towards the unaffected side. The *masseur* stands behind the patient, and places his hands (previously anointed with pure vaseline) in such a way that one forefinger is in contact with the insertion of the auricle behind, while the other is in front of the tragus. Then commencing very gently, but afterwards increasing the pressure, he passes his hands downwards as far as the clavicle and the top of the shoulder. The pressure is made chiefly in the hollow between the lower jaw and the sterno-mastoid, and over the vessels along the inner border of the muscle. The rubbing should be practised twice or three times daily, and for three to five minutes on each occasion. In acute cases it is well to wait until febrile symptoms have subsided.

---

* The native doctors in India use partially charred cotton-wool to check bleeding from leech-bites.

† Schwartze, *Handbuch der Ohrenheilkunde* (Bd. I., S. 683), and Murrell, *Masso-therapeutics*, page 52.

Massage of the auricle is likely to prove useful in cases of othæmatoma. It is also recommended by Politzer for chronic catarrh and congestion of the Eustachian tubes. Friction is to be employed for two to three minutes on the side of the neck, below the auricle, between the ramus of the lower jaw and the mastoid process. Severe otalgia, accompanied by tenderness in this region, is likely to be relieved by similar treatment.

The effect of massage upon the auditory nerve has been especially studied by Urbantschitsch.* He states that massage of the side and back of the neck is often of great benefit in cases of *tinnitus aurium*. His experiments also show that massage of the regions supplied by branches of the auriculo-temporal and supra-orbital nerves often produces a remarkable and permanent improvement in many cases of labyrinthine deafness and subjective sensations, which other modes of treatment had failed to benefit. In other cases, massage appeared to reinforce the effects of other remedies. He advises that friction should be made from the forehead to the tragus, with firm pressure over the supra- and infra-orbital foramina; along the course of the temporal nerve, and especially over the tragus and the area supplied by the auriculo-temporal. By causing the tragus to vibrate rapidly under moderate pressure, the subjective sensations are often materially relieved and the hearing power is improved. This result is obtained even when the tragus is not pressed down so as to close the meatus, as in Hommel's method. The good effects may, therefore, be attributed to stimulation of the fifth nerve.

The same author recommends massage of the Eustachian tube to be effected by passing a bougie (having a small rounded head) beyond the isthmus, and moving it alternately backwards and forwards for a few seconds, or even for a few minutes. He asserts that such treatment proves beneficial in cases of swelling of the tube, resulting from chronic catarrh of the tympanum; that it is more efficacious than simple dilatation; and that it improves the hearing-power and relieves the subjective sensations.

---

* *Lehrbuch der Ohrenheilkunde*, Dritte Aufl., S. 476.

With reference to this last plan of treatment, the author can only repeat the opinion already expressed (see page 140). He questions its efficacy, and is sure that serious injury to the tube and tympanum might be very easily caused.

References to other mechanical methods of acting upon the structures of the ear will be found in the chapters on Chronic Adhesive Catarrh and Chronic Suppuration of the Middle Ear. The most important of these are the plans devised by Hommel, Delstanche, and Lucæ.

(5) **The Introduction of Medicated Solutions into the Meatus.**—Liquid remedies may be introduced into the auditory canal either by pouring them directly from the receptacle in which they have been warmed, or by saturating a piece of cotton-wool and using the aural forceps. This latter method is sometimes employed in the treatment of diseases of the external meatus. Before introducing the liquid, the meatus should be properly cleansed, either by syringing or with cotton-wool; and if by the former method, the meatus must be carefully dried. The fluid should always be warmed before introduction, and this is best done by putting the requisite quantity into a small test-tube, and then placing the test-tube in water of the required temperature. The practice of warming drops in a spoon held over a candle or lamp is liable to result in the ear being scalded, because the degree to which the drops have been heated cannot be estimated. If a test-tube is not at hand, a small phial may be used instead. If it be desired to affect only the tympanic cavity, five to ten drops will be sufficient; but to act on the meatus twenty drops or more will be required, according to its size.

The patient's head should be in such a position that the affected ear is directed upwards, and the auricle should be drawn upwards, backwards, and outwards. If the object be to act upon the middle ear, in cases of perforation of the membrane, the fluid may be forced inwards by making pressure on the tragus. The attempt, however, is not always successful, even when a large perforation exists. Gruber's* experiments show that, under the above circumstances, fluids instilled into the auditory meatus pass easily into the tympanum, provided that the structures of the external and middle ear are otherwise normal. Liquids thus introduced escape through the Eustachian tube without entering the mastoid cells, if the head of the patient be bent over as usual towards the opposite shoulder. When the Eustachian tube is completely occluded, and perforation exists in the membrane, a portion of the fluid can enter the tympanum, if there be sufficient space for its reception; and if, at the same time, the mastoid cells are accessible and contain air, some of the fluid may pass into those cavities, the air being either displaced or compressed. If with an aperture existing in the membrane, the liquid introduced into the tympanic cavity does not escape through the Eustachian tube when the head is inclined towards the opposite shoulder, it may be inferred that obstruction exists either in the tympanum or in the tube itself.

When a perforation exists in the membrane, fluids may be driven into the tympanum, and through the Eustachian tube, by the plan suggested by Politzer. After pouring the liquid into the meatus, the nozzle connected with the tube of an air-bag is fitted closely into the aperture. On compressing the bag, the air and the fluid are forced into the tympanum and through the Eustachian tube, if the latter be permeable; swallowing a mouthful of fluid whilst the nostrils are compressed produces a similar result.

Solutions introduced into the meatus should be allowed to remain for several minutes, and then removed either by bending the head towards the affected side, or by introducing absorbent wool into the meatus. A plug of wool should be inserted after the parts have been thoroughly dried.

(6) **The Insufflation of Remedies in the Form of Powders.**—Drugs intended to be used by insufflation should be reduced to *very fine powder*, for otherwise they are liable to irritate the parts and form masses which may obstruct the canal. Thorough cleansing and drying are necessary before insufflation. The simplest instrument for this purpose consists of a glass tube or portion of a quill, to one end of which a piece of india-rubber tubing may be attached with advantage. The powder may be blown into the auditory canal, either by the mouth or with the aid

---

* *Zeitschrift für Praktische Heilkunde*, 1864.

of an india-rubber bag. Some years ago the author contrived the insufflator* shown at Fig. 59. It consists of a vulcanite tube four inches in length, having attached to one end a piece of india-rubber tubing about fifteen inches long, fitted with a mouthpiece, *d*. There is an aperture, *a*, in the tube for introducing the powder, and a sliding ring, *b*, which covers the aperture as shown at *b′*. There is a valve between the aperture *a* and the india-rubber tubing to prevent powder being drawn by accident into the mouth. The length of tubing mentioned enables the instrument to be used either as an insufflator or as an auto-insufflator.

(7) **The Air-Douche and Injections through the Eustachian Tube.**—The various methods of inflating the middle ear have already been described; they are frequently employed in the treatment of aural diseases. The principal purposes which they subserve are:—The ventilation of the tympanum, the restoration of the membrane and chain of bones to a normal position in cases in which these structures have been unduly pressed inwards, and the scattering and removal of secretion from the tympanum. The reasons for selecting any particular method will be given in the chapters dealing with those diseases to which these methods are applicable. It is sufficient to repeat the remark that when liquids or vapours are to be introduced through the Eustachian tube into the middle ear, the catheter is generally indispensable. It must, however, be borne in mind that, except

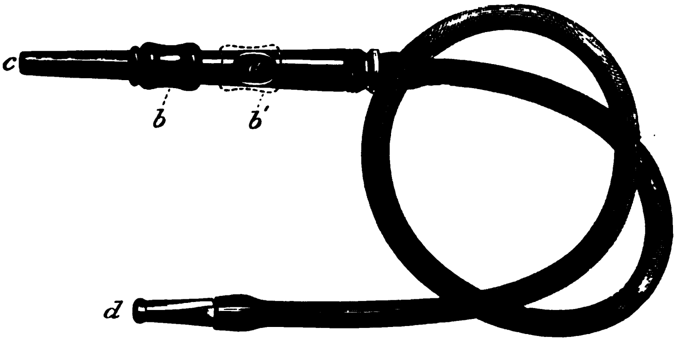


Fig. 59.

The Author's Aural Auto-Insufflator. (Half-size.)

---

* The insufflator may be obtained from Messrs. Mayer & Meltzer, 71, Great Portland Street, London.

in the form of spray, fluid should never be injected into the tympanum unless there is a perforation in the membrana tympani to allow of its escape.

The introduction of fluids into the tympanum should be done in the following manner:—When the catheter has been passed into position, the patient's head should be placed so that the catheter is horizontal. One or two drops of the fluid should then be injected by means of a syringe with a nozzle which does not fit the catheter tightly. The object of this is to prevent the fluid being forced directly into the tympanum. An air-bag (previously suspended from a button on the operator's coat), with a nozzle which accurately fits the catheter, should then be used; its compression will cause the fluid to enter the Eustachian tube in the form of spray. If the nostrils are sensitive, a few drops of a 2 per cent. solution of cocaine may be sprayed into them before the operation is commenced. The quantity which reaches the tympanum depends on the condition of the walls of the cavity and of the Eustachian tube, and on the force with which the fluid is injected. It is also dependent upon the distance to which the catheter is passed. If the point of the instrument is not placed well against the orifice of the tube, the greater portion of the injected liquid will escape into the pharynx. The passage of fluid into the tympanic cavity can be recognised by auscultation; bubbling or crackling râles are heard, and appear to originate close to the ear of the listener.

Fluids may likewise be forced through the Eustachian tube without using the catheter, but there are various difficulties and dangers connected with all the methods that have been proposed. Without a catheter it is all but impossible to limit the injection to one tube, and to regulate the quantity of fluid which passes to the tympanic cavities. The consequences of an excess are apt to be very serious; violent inflammation of the middle ear has been thus caused, and in other cases the injection has produced intense pain, severe giddiness, and syncope.

Professor Gruber, however, recommends a plan whereby fluids can be conveyed into the Eustachian tubes without the use of the catheter. He points out that in cases in which the naso-pharynx is seriously affected, the introduction of the catheter is likely to cause much irritation, which aggravates the condition of the middle ear, and may thus counteract any benefit resulting from the injection. He uses a syringe capable of containing about three ounces, and with an olive-shaped nozzle sufficiently large to permit the nostril to be completely closed after its insertion. Having filled the syringe, the surgeon raises the tip of the nose with his left thumb, and inserts the nozzle within one nostril, while closing the other with his left index finger. The syringe, held horizontally, is then emptied with the requisite amount of force. The soft palate is instinctively made tense, so as to shut off the naso-pharynx below, and the tongue is drawn back, so as to close the passage more firmly. The liquid which enters the post-nasal space flows round towards the opposite Eustachian orifice, and so into the other side of the nose. If the latter be closed, the liquid, under the pressure employed, passes through the Eustachian tube, when patent, towards the middle ear. Professor Gruber claims that this method is especially suitable for children; but the author is of opinion that it ought not to be employed unless the membrana tympani on each side is largely perforated.

The same authority asserts that liquids may be introduced into one Eustachian tube by the following process: The patient bends his head over towards the shoulder of the same side as the ear to be treated, and inclines his face somewhat downwards. From thirty to fifty drops of the fluid are then introduced into the lower nasal meatus of the affected side by means of a small syringe. As the latter is withdrawn, the surgeon closes the nostrils with his finger and thumb, and directs the patient to make a forcible expiration with the mouth closed, as in Valsalva's method. A portion of the injected fluid will pass into the mouth of the Eustachian tube on the lower side.

If there be a perforation in the tympanic membrane on each side, Gruber's method, and a somewhat similar plan recommended by Politzer, may be advantageously employed in some cases. If, however, there be a perforation only on one side, a catheter ought to be used, by the aid of which it is often possible to wash out the tympanum more thoroughly than can be accomplished by syringing the meatus. The catheter used for this purpose should be somewhat sharply curved, and introduced as far as possible into the tube. Air should be first injected in order to ascertain that the catheter is in the proper position; the nozzle of the syringe is then introduced into the mouth of the catheter, and the fluid is slowly injected. There is sometimes considerable resistance to the passage of the fluid, but with a little practice it may often be driven in a continuous stream from the external meatus. The passage of the fluid is facilitated by causing the patient to make several swallowing movements.

The Injection of Vapours and Gases through the Eustachian Tube.—Steam is sometimes injected into the middle ear in cases of chronic adhesive inflammation. The apparatus required is as follows: A spirit lamp and a flask half-filled with water, and having in its cork or stopper two holes, for the reception of two glass tubes; a piece of flexible rubber tubing is attached to the outer end of each tube. It is well to make another small opening in the cork to provide for the escape of superfluous steam. An air-bag is connected with the free end of one of the rubber tubes; the end of the second tube terminates in a nozzle adapted to the Eustachian catheter, which should be made of vulcanite. The steam is driven into the catheter by compressing the bag somewhat quickly, and after each injection the nozzle should be removed from the catheter. Dr. Roosa* recommends the combined vapours of iodine and camphor. He adds two drachms of the latter to two ounces of tincture of iodine, in a wide-mouthed flask. Two tubes pass through the cork; one of these reaches nearly to the surface of the liquid, while its other extremity is attached to an air-bag. The other tube just passes through the cork; its other end is fitted with a nozzle adapted to the Eustachian catheter. The patient holds the apparatus in his hand, while the surgeon forces the vapour into the mouth of the catheter.

The vapour of chloride of ammonium has been used by some surgeons; it was introduced for this purpose by v. Tröltsch. The apparatus he devised consists of three flasks, connected with each other by glass tubes. The flasks contain respectively strong ammonia, hydrochloric acid, and acidulated water. When air is driven into the two first bottles, it conveys the vapours to the third, where the chloride of ammonium is generated. A tube leading from this bottle carries the vapour to the mouth of a catheter in the Eustachian tube. Various other apparatus for the generation of chloride of ammonium vapour may be obtained from instrument makers. When chloride of ammonium vapour is used care should be taken that it is thick and neutral, both of which conditions will be obtained if the acid and ammonia are properly mixed.

---

* *Treatise on Diseases of the Ear*, p. 401.

Air impregnated with the vapours of æther, chloroform, and turpentine is sometimes injected into the middle ear. The method of procedure is very simple. A small quantity of the fluid is poured into a bottle and gently warmed. The nozzle of an air-bag which has been compressed is then placed in the neck of the bottle, and the bag is allowed to expand. The air thus charged with the vapour is then injected into the catheter in the ordinary way.

In using vapours of any kind in the manner above described, care must be taken that they are not too hot, and that they are not likely to irritate the throat or ear.

(8) **Constitutional Treatment.**—It seems desirable to add a few remarks on the constitutional treatment of patients suffering from aural diseases, leaving the hygiene of the ear to be dealt with in a separate chapter.

Many diseases of the ear are more or less closely connected with general or constitutional disorders—sometimes obvious, but often discoverable only after careful examination. Even if the local disease be not distinctly traceable to the constitutional malady, its severity may be aggravated and its course may be prolonged by the influence of the latter. The general disorders most prone to affect the ear in one or other of these ways are tuberculosis, syphilis, anæmia, gout, and rheumatism. When any one of these exists, local treatment, however well directed, is not sufficient; it should always be supplemented by measures adapted to cure or to relieve the general disorder.

Protection against cold and damp is highly desirable, and especially for patients suffering from diseases of the middle ear, the result of extension from the naso-pharynx. The original disorder should, of course, be carefully treated; the patients should be well clothed, should avoid exposure of the head to cold draughts, and, when possible, should live in well-ventilated rooms and in a dry, healthy situation. Children suffering from this form of disorder should not be allowed to remain at school, but should be sent to the seaside or to some country place where the hygienic conditions are favourable. In all cases attention to details with regard to food, exercise, rest, cleanliness, ventilation of rooms, and general manner of living will help to cure the local disorder. Excesses of all kinds must, of course, be avoided, and, as a general rule, tobacco should be prohibited.

Chronic catarrh and chronic suppuration of the middle ear are often benefited by a sojourn, during the summer months, in a mountainous district, of moderate elevation and sheltered from cold winds. In winter a warm, dry locality should be selected. Similar changes of climate may be recommended for cases of adhesive catarrh. Baths, of various kinds, by improving the general health, sometimes act favourably upon the local disorder. As a general rule, cold baths should be forbidden in cases of middle ear disease. When the tympanic membrane is perforated, bathing in the sea or in rivers, with immersion of the head, is likely to prove mischievous. If, however, the local processes be at a standstill, the weather favourable, and the patient robust, bathing may be allowed, provided that the meatus on each side is perfectly occluded by a plug of cotton-wool, or, still better, by an aural protector. Warm baths, with either fresh or salt water, may always be allowed.

The various medicinal remedies used in the treatment of diseases of the ear, and the indications for their employment, will be specified in succeeding chapters.

CHAPTER VII.

DISEASES OF THE EXTERNAL EAR.

MALFORMATIONS OF THE AURICLE AND EXTERNAL MEATUS.

CONGENITAL malformations and defects of various kinds not infrequently occur in the external ear. They may be described under the headings of (1) absence, (2) defective development, (3) plurality, (4) abnormal size and shape of the auricles and meatus, and (5) abnormal positions.

Complete Absence of the Auricle is a very rare condition; on the other hand, malformations due to defective development are somewhat common and of very various degrees. They may be comparatively inconspicuous, and take the form of stunted development of some portion of the auricle; or the latter may be quite rudimentary, and represented only by a fold of integument and a fragment of cartilage. Between these extremes there are many intermediate forms. In a not very uncommon form, the posterior border of the helix appears to have become adherent to the tragus, thus covering the meatus. The influence of heredity is sometimes noticed. Rohrer has met with seven members of one family, in all of whom there was entire absence of the lobule on both sides. Examples of defective development of the helix and lobule are most common among insane persons. The defects may be either bilateral or confined to one side; but a rudimentary auricle on each side is rarely noticed.

Incomplete development of the external ear, when of a marked character, very seldom exists alone. It is generally associated with deficiency or absence of the tympanic ring, and therefore of the osseous portion of the meatus, and with imperfect development of the tympanum and ossicles. In some cases there is no trace of a meatus; in others there is only a short and blind passage. Serious abnormalities of the external ear are likewise apt to be connected with defective development of the lower and upper jaws, and of the sphenoid and palate bones. Hare lip and cleft palate are not uncommon in such cases, and unilateral malformations are often associated with defective symmetry of the two sides of the skull. On the other hand, malformations of other parts of the ear very rarely co-exist with a normal auricle.

Supernumerary Auricles and multiplicity of various portions are not uncommon. Wilde cites the case of "a child with four ears, two naturally placed and two lower down on the neck; there were in this instance two petrous portions in each temporal bone." A similar case is reported by Mr. Birkett.* A young girl, in addition to irregularities in her ears, had on each side, over the middle of the sterno-mastoid muscle, a large growth resembling the lobule of the ear, and containing fibro-cartilage and a small artery. According to the late Sir J. Paget, supernumerary auricles are found only over the lines of former branchial fissures, and may be considered as cutaneous opercular growths, homologous, though abnormally, with the natural auricles, which guard the first cleft. Supernumerary portions, termed auricular appendices, are most often found near the tragus and lobule. This latter part sometimes presents a perpendicular cleft,

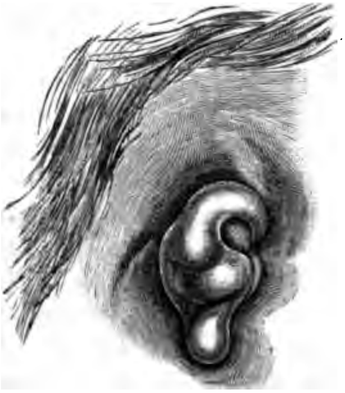


FIG. 60.

MALFORMATION OF THE AURICLE. (*Gruber.*)

---

* *Trans. of Path. Soc.*, 1858, vol. ix. p. 448.

extending from its apex. Absence of a definite anterior border to the lobule is often noticeable.

Abnormal Size and Shape of the Auricles.—In one class of cases one or both auricles are excessively large; in another, an opposite condition is noticed. Symmetrical enlargement of the whole auricle is comparatively rare; but increased size of various portions is not uncommon, and may be artificially induced. Thus, hypertrophy of the lobule, often seen in women in Eastern countries, is the result of wearing heavy earrings. A very small auricle is sometimes met with, either having all its parts perfect, or more or less defective. A little projection on the margin of the helix at the upper part is not infrequent, and is sometimes very distinct. It represents the pointed extremity in the expanded ears of quadrupeds. Sometimes the ear resembles that of an animal.

Anomalies of Position.—Mention has been already made of those cases in which the auricle is attached to the neck, side of the face, &c. In another class of cases, the auricle is normally attached to the head, but the expanded part, instead of lying more or less close to the skull, stands out almost at a right angle. In an opposite class, the auricle is adherent to the side of the head. Havelock Ellis* states that projecting and large ears are especially frequent among criminals, and that they constitute the peculiarity most often noticed. It has been suggested that the position of the auricle in these cases is due to mechanical causes, *e.g.*, "pulling the ears," or the influence of headgear, &c. The peculiarity is, however, most probably congenital, and may amount to a deformity.

Malformations of the External Meatus are often accompanied by similar conditions of the auricle and tympanum. The passage may be entirely absent, or represented only by a blind cleft or fissure, or by several minute canals. In another class of cases there are two distinct auditory passages, either communicating with each other or remaining separate. In one recorded instance, the supernumerary passage was behind the auricle, and extended to the tympanic membrane. Diminished calibre of the meatus is frequent among deaf and dumb children. A similar condition of the cartilaginous meatus sometimes occurs in old age, and is due to relaxation of the part, and especially of those fibres by which the membranous portion is attached to the squamous bone. Projections in the wall of the meatus likewise diminish its calibre, and the same result is produced by chronic inflammatory conditions leading to thickening of the walls, by cicatricial contraction, and various morbid growths. Acquired atresia may be due to chronic eczema of the meatus.

---

* "The Criminal," p. 65. See also Gradenigo, *Arch. f. Ohrenheilkunde*, Bd. XXX. S. 230, and Bd. XXXII. S. 202.

Dr. Eugen Joel* has collected eleven carefully recorded cases of congenital closure of the meatus. In almost every instance the osseous position of the auditory canal was represented by a mass of compact or cancellous tissue; occasionally a small defect in the bone could be observed, and in some specimens a narrow fissure led into the tympanum. In most cases the rudimentary auricle exhibited traces of an auditory aperture in the shape of a shallow depression; but in some instances no such trace of a meatus could be discovered. The cartilaginous portion of the auditory canal was occasionally present, and formed a pouch, closed at the tympanic end. The tympanic bone and the membrana tympani were invariably absent; the tympanum was either much narrowed or replaced by osseous tissue; the ossicles were either entirely missing or imperfectly developed, whereas the labyrinth was rarely affected. In cases of bilateral congenital atresia, the structures of the internal ear are generally normal; and, when properly educated, the children are able to hear and understand ordinary conversation, the words, of course, being uttered close to their ears.

Closure of the meatus by membranous formations is sometimes congenital,† and either the commencement of the canal or the passage itself may be thus affected. Urbantschitsch points out that the tissue blocking up the meatus consists of epithelium alone, and does not contain any of the deeper structures of the cutis. In some animals—*e.g.*, dogs, cats, rabbits, and mice—such occlusion of the meatus at birth is a normal condition; the epithelial tissue subsequently undergoes retrogressive metamorphosis.

Prognosis.—In cases of severe congenital malformation of the auricle, no definite forecast can be made as to the hearing-power of the child. Regard must always be paid to the probability of a similar condition of the tympanum and labyrinth. When the child is more than six months old, and fails to start when loud sounds are produced near to it or to turn its eyes in their direction, the conclusion is inevitable that hearing-power is absent. If the malformation be unilateral, the unaffected ear should of course be closed during the experiments.

---

* *Archives of Otology*, vol. xviii. p. 317.

† See a case recorded by Dr. Knapp, *Archives of Otology*, vol. xi. p. 19.

Treatment.—In cases of absence of the meatus, attempts have been made to form a canal leading from the defective auricle to the tympanum. The results are almost always unsatisfactory, inasmuch as the middle ear is rarely normal, and the position of the auricle may be no guide to that of the deeper structures. It might, however, be justifiable, in cases of bilateral atresia of the meatus, to make an exploratory incision towards the membrana tympani, and to endeavour to create a canal by means of sponge tents. No operation is practicable in cases in which an osseous mass occupies the place of the auditory meatus. When the malformation is unilateral, it is unadvisable to interfere with it, except, perhaps, in cases of adults in whom Weber's experiment (page 99) yields fair evidence of a normal condition of the deep structures on the affected side. If the obstruction be membranous in character, it may, of course, be divided with some prospect of success. Occlusion due to this cause sometimes results from chronic catarrh of the middle ear, with implication of the meatus.*

When the auricle is very small and much deformed, the patient's appearance will be improved by its removal and the application of an artificial substitute. Redundant portions of the auricle may likewise be removed with the knife or scissors; and when the whole auricle is abnormally large, improvement may sometimes be effected by the judicious curtailment of various portions.

The surgeon is sometimes called upon to rectify the deformity of a projecting auricle. Bandages and pads may be tried, but much time and patience would be required for any improvement, and they seldom prove efficacious. In marked cases, when the patients are very anxious to have something done, improvement may be effected by removing a piece of integument from the angle behind the ear. A curved incision, with the concavity looking inwards, is made on the auricle, and another of a similar character over the root of the mastoid process. The elliptical portion of skin is then removed by careful dissection. The integument is separated from its attachments for a little distance along the margin of the wound, and the edges are carefully brought together by suture; a bandage is applied so as to keep the ear close to the head until union has taken place. This operation generally yields satisfactory results, but in cases in which the deformity is considerable it is often necessary to remove a portion of the cartilage.

---

* *Archives of Otology*, vol. xv. p. 75.

Congenital Aural Fistulæ.—The last class of malformations requiring notice includes the so-called "congenital fistulæ of the auricle." These are small canals, the openings of which are usually found near the tragus and on the anterior portion of the helix. They are only a few millimetres deep, and often contain a whitish fluid; small cysts are apt to result from occlusion of the orifices. They are sometimes noticed in several members of the same family, and are occasionally traceable through several generations. They have no anatomical relationship to the canals or cavities of the ear, but are the remains of the first branchial cleft, and are therefore wrongly named "aural fistulæ." They sometimes come under the notice of the surgeon when their walls become inflamed, as a result of the entrance of foreign bodies, and when they are converted into cysts. A case of this kind has been recently reported by Mr. A. H. Cheatle.* The opening was just in front of the anterior extremity of the helix and had existed during the patient's life. Inflammation set in from time to time, and abscesses formed which, on bursting or being opened, left an ulcer which healed up under simple treatment, the fistulous track alone remaining. In this case, the sinus had several branches; these were freely laid open. Pure carbolic acid was applied to the wound, which was packed with double cyanide gauze. Complete healing took place in a few weeks. The late Sir James Paget† recorded several instances of branchial fistulæ in the external ears occurring in the family of a gentleman, perfectly well formed in other respects, but having a branchial fistula on the right side of the neck. "His father and a sister, as well as four of his own children, had similar malformations; the fistula in two of the latter being on the left side, and in the other two symmetrically disposed on each side of the neck. But in addition to these cervical fistulæ, the gentleman himself, his sister, and five of his children, each presents fistulæ in the helix of one or both ears." These corresponded with the description given above; they were less soft and flexible than the cervical fistulæ, producing no secretion, and causing no annoyance. Sir J. Paget regarded these aural fistulæ as probably due to the incomplete closure of the upper, or post-oral fissure. The membrane lining the branchial fistulæ is apt to show signs of irritability when touched with a fine probe. Convulsive attacks of coughing may be thus induced.

---

* *Archives of Otology*, vol. xxvi. No. 2, 1897.

† In a paper read before the Med.-Chir. Society, Nov. 27, 1877. See *Lancet*, Dec. 1, 1877.

CHAPTER VIII.

DISORDERS OF THE SECRETION IN THE AUDITORY MEATUS—ACCUMULATION OF CERUMEN—KERATOSIS OBTURANS.

UNDER normal conditions, the secretion of the ceruminous glands is sufficient only to lubricate the surface of the cartilaginous portion of the meatus; but increase of the secretion is not infrequent, and is due to a variety of causes. The fluid yielded by the glands is normally of a light-yellow colour, and becomes converted into thin dry scales. When the secretion is in excess, these scales form soft masses, which eventually become hard and brittle, and more or less occlude the meatus. Their colour changes from light yellow to dark brown or black; and in the course of time they form ragged plugs, sometimes displaying bright facets on their surface, owing to the presence of cholesterin. Besides the secretion from the ceruminal glands, these plugs contain epidermic scales and hairs, with particles of dust ; and in diabetic cases sugar can sometimes be detected. Various forms of bacteria are generally present.

Causes.—Ceruminous plugs are due either to abnormally increased activity of the glands, or to obstacles to the escape of their secretion. They are far more common in males than in females. Increased glandular activity is sometimes noticed in individuals whose skin evinces a similar condition. Increase and hardening of cerumen may occur alone, or may be symptomatic of irritation of the external or middle ear; the author is inclined to attribute the formation of such plugs almost invariably to this cause. The diseases and conditions in which the accumulation may occur are (1) chronic catarrhal inflammation of the tympanum; (2) chronic suppuration of the tympanum ; (3) diffuse inflammation of the auditory canal; (4) foreign bodies; (5) parasitic inflammation. Hardening of the cerumen also occurs in disease of the internal ear, and in these cases removal of the wax may slightly, or even considerably, improve the hearing. To these may be added eczema of the meatus and improper methods of cleansing the canal, *e.g.*, with a pointed piece of towel, by which the secretion is pushed more deeply into the ear. Politzer's observation that ceruminal accumulation is much more often found in those who cleanse the meatus than in those who neglect it coincides with the experience of most aurists. Under normal conditions, the motions of the jaw tend to remove dry scales of cerumen. With regard to obstacles to the escape of the secretion, it is evident that constrictions of the meatus and exostoses of the canal are likely to act in this manner; and foreign bodies may be included in the same category.

Symptoms.—Inspissated cerumen may remain in the meatus for considerable periods without causing any subjective symptoms, provided only that a passage be left for the transmission of sonorous impressions to the tympanum. It is to the position rather than to the quantity of the accumulated cerumen that the symptoms are likely to be due. These consist in more or less marked deafness, a sensation of fulness in the ear, tinnitus and giddiness, the two latter being the result of pressure upon the membrana tympani. As a general rule, plugs of cerumen do not materially affect the hearing until they occlude the meatus. Deafness may occur quite suddenly, owing to displacement of the hardened material, or to its becoming swollen, in consequence of the entrance of water into the ear. If the walls of the meatus be irritated by the mass, the irritation may be conveyed to the auditory nerve by the branches of the fifth pair, and various abnormal sounds may be heard. Pain in the ear is less frequently experienced, but it may be very severe, and extend to other parts of the head and to the neck. Motor disorders have been occasionally observed, *e.g.*, blepharo-spasm, and facial paralysis, the symptoms disappearing after removal of the plug. Great depression of spirits, almost amounting to melancholia, is occasionally observed; the relief obtained by removal of the plug indicates the cause of the mental symptoms. Cough is sometimes complained of, the irritation being conveyed either directly by the auricular branch of the vagus, or by the auriculo-temporal of the fifth to the latter nerve, the deep origin of which is close to that of the sensory root of the fifth nerve. The medulla oblongata is accustomed to receive impressions through the vagus from the larynx, and hence the irritation occurring in the ear is referred to that organ. In a case recorded by Mr. Percy Jakins,[*] the cough, which had existed for four years, was accompanied by gradually increasing weakness, night-sweats, and occasional delirium. The patient was supposed to be consumptive; but all the symptoms rapidly disappeared after removal of cerumen from both ears. More than thirty years ago, Dr. C. Fox[†] drew attention to the fact that cough can often be excited by irritation of the external auditory meatus. Not only the presence of cerumen, but the introduction of a probe or other similar instrument into the meatus, may excite a fit of coughing. Sometimes the action is excited in the reverse direction, as when long-continued singing causes pain in the ear.

On examining the ear, the cerumen may be found to cover several spots, or to occupy the canal in the form of scales or crusts or rounded masses, but it is often seen as a dark brown or black plug, extending from the orifice of the meatus down to the membrana tympani. Occasionally a plug of this character is covered by concentric layers of epidermic scales, which envelope it like a sac. These scales may, indeed, form the greater part of the plug. In children, the wax is generally yellowish, and deposited in layers. After the removal of the accumulation by the aid of the syringe, the surface of the meatus and the membrane are often seen to be reddened and injected, but these appearances are due in great measure to the irritation of the syringing. In some cases the accumulated masses set up inflammation, and even ulceration, in the meatus. Other changes sometimes seen are the result of pressure; thus the membrana tympani may be pushed inwards, and in a condition of atrophy, while sometimes openings form. In other cases the effects of pressure are seen in the walls of the canal, which are atrophied and partially destroyed, so that the meatus is dilated, and the cerumen may pass into the tympanum, and likewise into the mastoid cells. It is possible that, in these cases, the accumulation of cerumen was the result of chronic suppuration, which was also the real cause of the damage to the meatus. In very rare cases the ceruminous material is found to enclose a hard mass, consisting mainly of carbonate of lime.

---

[*] *Practitioner*, 1887, vol. i. p. 423.

[†] *Lancet*, 1866, vol. i. p. 451.

The Diagnosis of ceruminal accumulation is, for the most part, easily made; the speculum may be required, but examination with the naked eye is often sufficient. The meatus is seen to be occupied by a yellow or brownish mass, the consistence of which varies greatly. Foreign bodies in the ear, and especially plugs of cotton-wool, inspissated discharges, and epithelial masses, may be mistaken for accumulations of cerumen. In all obscure cases of cerebral disorder, the ear should be very carefully examined. A case is recorded by v. Tröltsch* of a patient who, after a fall, suddenly became giddy and deaf, and was treated by various remedies, including the application of a seton. It was found on careful examination that a plug of cerumen was the cause of the symptoms.

The Prognosis in cases of inspissated cerumen may be somewhat uncertain, inasmuch as the condition is not infrequently associated with other affections of the ear. If the deafness has come on rapidly, and improvement spontaneously occurs from time to time, a plug of cerumen is likely to be present. If the tuning-fork, placed on the head, be indistinctly heard on the occluded side, some affection of the internal ear may be suspected. It was pointed out by Toynbee that ceruminal accumulation often exists in cases of adhesive processes in the middle ear, and of affections of the labyrinth. Intermittent loss of bone conduction has been noticed in some cases of plugging of the meatus by cerumen; it passes off after the wax has been removed. It must be remembered that recurrence of accumulation is not uncommon, even in persons of cleanly habits.

Treatment.—The removal of ceruminal accumulation is best effected by syringing the ear with warm water (temperature 100° to 105° Fahrenheit). If the plug be dry and hard, it is better, before using the syringe, to soften it by filling the meatus with warm water. The water should be allowed to remain for several minutes, and it must be remembered that the immediate effect will probably be an increase of deafness and tinnitus, this being due to the swelling of the plug. If the mass does not come away readily on the syringe being used, after water has been allowed to remain in the meatus for a few minutes, it may be *gently* separated from the wall of the meatus by means of a chromic acid carrier or a probe, so as to allow the stream of water from the syringe to pass inwards. This should never be done without a strong light being thrown at the time through a speculum upon the plug, for fear of injury to the neighbouring structures. If this procedure causes pain, and but little wax is removed when the ear is again syringed, it is best to wait until the mass has been softened by other means before a further attempt is made to get it away. Plugs largely composed of concentric epithelial scales are apt to adhere very closely to the walls of the meatus.

---

* *Lehrbuch der Ohrenheilkunde*, 1881, S. 95.

For softening cerumen the following formula is suitable:—

℞.	Sodii Bicarb.	gr. x.
	Glycerini	ʒij.
	Aq. Destill.	ʒij. Misce.

A few drops to be warmed, and placed in the ear several times a day, until the mass has become thoroughly softened. The ear should be carefully examined during the syringing process, lest the latter should be continued after all the cerumen has come away. After complete removal of the plug, the hearing is in most cases improved, and the subjective symptoms disappear, but normal hearing is not generally obtained, because the accumulation of cerumen is usually secondary to some other affection. The meatus should be carefully dried with absorbent wool, and a small plug of cotton-wool should be introduced, and renewed from time to time for several days, if the weather be cold or damp. The cutis and the membrana tympani are apt to be very sensitive after a plug has been removed. The author has found the instillation of a few drops of solution of peroxide of hydrogen* an efficient aid in the removal of cerumen. The fluid should first be warmed by placing it in a test-tube immersed in hot water and then poured into the meatus. The mass becomes so rapidly disintegrated, even when very hard, that in a few minutes it appears as if honeycombed, and can easily be removed by syringing. Accumulations of cerumen are very liable to recur, and, therefore, it is well for the ear to be examined from time to time, and syringed when necessary.

---

* This plan appears to have been first recommended by a writer in the *Maryland Medical Journal*, vol. xxxix. No. 20.

An opposite condition, namely, **Deficiency of Cerumen,** far less frequently occurs, but it sometimes happens without any apparent cause, and sometimes associated with disorders of the middle ear, as a result of some affection of the trophic nerves. Marked dryness of the meatus is often an early symptom of adhesive inflammation of the middle ear. Inflammatory processes in the meatus also check the secretion of cerumen, and the same result is sometimes due to senile atrophy of the glands. Frequently washing the meatus is said to diminish the secretion. The symptoms of this condition are a feeling of dryness and irritation in the meatus, which on examination is seen to be pale and dull. There is no necessary impairment of hearing, and when this symptom is present, being due to disorder of the middle ear, the reappearance of cerumen is by no means a certain indication of improvement.

Treatment.—In order to relieve the irritation, a little vaseline, vinolia, or glycerine may be applied to the meatus, and if these fail, white precipitate ointment may be tried.

Keratosis Obturans, or Laminated Epithelial Plug of the External Meatus.—In addition to obstruction caused by accumulation of cerumen, the external meatus is sometimes occluded by layers of epithelium. This condition was first described in 1874 by Wreden,* of St. Petersburg, who termed it "keratosis obturans," in contradistinction to ceruminosis. Although by no means infrequent, this disease of the meatus has since been noticed by very few authors—in fact, the only detailed account is to be found in Dr. Burnett's work.†

Keratosis obturans of the external meatus is the result of chronic desquamative dermatitis, in which layers of epidermis, closely packed together, gradually accumulate in the deeper part and cause marked deafness and more or less discomfort. A small quantity of cerumen is sometimes found between the layers, and covering the outer surface of the plug. No definite cause can be assigned for the production of these masses; they were found by Wreden sometimes to contain vegetable spores, which, however, he did not consider as the originators of the disease. Mr. R. Lake* believes that the affection is caused by the irritation set up by a plug of cerumen, and that it is really a dry, scaly eczema. Burnett suggests that the chronic dermatitis and desquamation may be set up and favoured by frequent attempts to cleanse the ear in a somewhat rough fashion. "Excoriation is first brought about, and then a slow exudation of dermoid cells goes on, and these desquamated elements of the cells are packed in and mechanically retained in the canal." As the mass becomes larger, it presses on the skin of the canal and tends to increase the irritation. Pain is felt not only in the meatus, but also around the ear and even over the temple.

---

* *Archiv f A und O.*, vol iii. p. 91.

† *A Treatise on the Ear*, p. 278.

The existence of keratosis obturans is usually not discovered until syringing fails to remove what was considered to be merely cerumen. It is then seen that the wax which was covering the mass has been washed away, and the meatus is found to be blocked up by a dense, firm obstacle, whitish or sometimes dark green in colour, and firmly adherent. When portions of this are removed and placed in water, they are found to consist of layers resembling sodden white parchment, and which do not break up and become partially dissolved, as is the case with masses of cerumen.

Treatment.—For the removal of these plugs, the mass should be gently separated from the wall of the meatus with a chromic acid carrier, so as to allow a stream of water from the syringe to pass inwards. After the plug has been loosened by repeated syringing, portions may be carefully removed with the forceps; and these processes are repeated until all has been brought away. Great caution is necessary in removing the portion nearest to the tympanic membrane. Carefully directed syringing will usually result in its detachment *en masse.* In the case of children, an anæsthetic is often required, as the meatus is generally tender, and the removal of the mass may occupy an hour or even longer. The plug is sometimes found to consist of several layers of epidermis enveloping a mass of cerumen, the desquamative process having commenced when the meatus was filled with wax. When once the removal of the mass has been begun, the manipulation should be proceeded with until the meatus has been cleared out. The injected water causes the epithelium to swell, and any remains of the mass would adhere more closely to the wall of the canal and would be more difficult to remove on a subsequent occasion.

---

* *Journal of Laryngology, Rhinology, and Otology,* Dec. 1895, p. 894

To prevent the possibility of the same condition recurring, the ear should be examined from time to time and syringed if required.

CHAPTER IX.

INJURIES OF THE AURICLE—BURNS AND SCALDS—FROSTBITES.

Injuries to the Auricle—*e.g.*, contusions, incised and lacerated wounds, either confined to this part or associated with injuries of adjacent structures—are of common occurrence. The symptoms and their severity depend upon the nature and degree of the force to which they are due. Portions of the auricle are sometimes completely separated, and union often results if the parts are brought into apposition and sutures are carefully applied. Such a favourable termination has been observed even when several hours have elapsed since the injury. A few instances* have been recorded in which the auricle was successfully replaced after complete severance. More or less severe injuries to the auricle often result from blows, either with the hand alone or with a stick or other weapon. The left ear most frequently suffers in this way. Piercing the ears (for the reception of ear-rings) is usually a harmless operation; but in rare cases, when a prolongation of the cartilage extends into the lobule, severe inflammation has been observed. In other cases, again, heavy ear-rings have been known to cut through the lobule. The condition known as othæmatoma, which is often of traumatic origin, will be described in a succeeding chapter.

Wounds of the auricle are to be treated according to the ordinary rules of surgery; antiseptic measures are easily carried out, and good results are generally attainable. When adjacent structures are also implicated, both treatment and prognosis must be correspondingly modified.

---

* *Lancet*, June 11, 1898.

Injuries to the External Meatus may be caused either by direct or indirect violence; and in both cases the neighbouring parts, viz., the auricle, the membrana tympani, and the petrous part of the temporal bone, are liable to be implicated. Fracture of the anterior wall may be caused by a blow on the lower jaw.

Direct injury to the meatus is often caused by foreign bodies, inserted either by accident or intentionally. These and their effects will be described in a succeeding chapter. The meatus is often involved in cases of injury to the auricle. Incised wounds, limited to the cartilaginous portion, are seldom, if ever, serious, though the parotid gland may be implicated; but cicatricial contraction may seriously diminish the calibre of the meatus. When the osseous part is injured, long-continued suppuration, followed also by contraction, is likely to result. Wounds of the posterior wall may extend into the mastoid cells, and there is always the risk that the injury to the deep part of the meatus may involve the tympanic membrane. Inflammatory processes after wounds may extend to the middle ear through the Glaserian fissure, as well as through the intervention of connective tissue and vessels.

The Diagnosis in these cases is for the most part easy, unless the meatus be very much swollen. Cold compresses should be applied, and the wounds may be subsequently dressed with boric acid ointment or other antiseptic. The risk of contraction should always be borne in mind. When necessary, laminaria or sponge tents may be introduced into the cartilaginous meatus, but their use requires great care.

Fracture of the Walls of the Meatus generally results from indirect violence—*e.g.*, a blow upon the lower jaw. In old persons this latter injury may easily cause a fracture of the glenoid fossa, and a blow on the chin may produce this result on both sides. In one case, the condyle of the lower jaw was driven into the meatus.* The upper wall of the canal is liable to be involved in cases of fracture of the base of the skull.

The symptoms of these injuries are not always very definite. Pain is, of course, complained of; crepitation can sometimes be detected, and there is usually more or less deformity. Hæmorrhage is likely to be profuse when the upper and posterior walls are involved; if the skin be not torn, the blood will accumulate under it. Escape of cerebro-spinal fluid does not necessarily indicate fracture of the meatus, for it occurs likewise in severe injuries of the labyrinth. In fractures involving the glenoid fossa, movement of the jaw will be painful and difficult.

---

* Gellé, *Précis des Maladies de l'Oreille*, p. 69.

Fractures involving the anterior and inferior walls of the meatus generally admit of a favourable prognosis. On the other hand, the prospect is bad when the superior wall is fractured, and especially when there is reason to suspect that the base of the skull is likewise injured.

Burns and Scalds.—The auricle is not often the seat of burns, unless the neighbouring parts are also involved. Scalds sometimes occur in persons, such as waiters and others, who are in the habit of carrying on their heads vessels containing hot fluids. The part is occasionally injured by mineral acids being thrown upon it, and extensive sloughs and ulceration are thereby caused. When the orifice of the meatus is involved, contraction is liable to ensue as a result of cicatrisation.

The treatment of burns of the auricle is the same as that of similar injuries elsewhere. Vesicles should be carefully pricked, so as to evacuate their contents and preserve the epidermis as a covering, and vaseline or boric acid ointment may then be applied. Either the liniment of lime or Carron oil (made with linseed oil) is a suitable dressing for more severe cases. When the inner surface of the auricle and the adjoining portion of the head are the seat of the burns, great care is necessary to prevent adhesion during cicatrisation. The parts must be kept separated by layers of cotton-wool or lint. Especial care is necessary in treating cases due to the effects of mineral acids. The extensive sloughing is apt to cause great destruction and considerable deformity, and when the meatus is involved, the aperture is likely to be more or less occluded. This result should be prevented as far as possible by keeping pledgets of lint and afterwards sponge tents in the opening.

Frostbite.—Owing to its exposed position the auricle is especially prone to exhibit the effects of severe cold. These are seen in various forms and stages; as a result of prolonged exposure to low temperatures, the auricle, like the nose, may become completely frozen, with necrosis and gangrene of portions of skin and cartilage as speedy consequences. In far more common cases, often seen in this country, circumscribed portions of the ear become red and swollen, the skin gives way and cracks, blood is discharged and crusts form. The most common sufferers from these so-called chilblains are young persons of both sexes, of delicate constitutions, and the effects of the cold are apt to manifest themselves every winter. It is not, however, necessary for the production of chilblains that the temperature should be below the freezing point.

The symptoms of chilblains are too well known to require description. When the ear is affected severe pain is complained of, associated with itching and a sensation of heat, which latter is apt to be very troublesome when the patient goes into a warm room.

The treatment of frostbite affecting the ear may be summed up in a few words. In recent cases soon after exposure the part should be rubbed with cold water or snow, and friction continued until circulation is restored. For the after-effects, circumscribed swellings may be painted over with a mixture of the tinctures of iodine and opium, or with collodion and iodol. Cracks and ulcers are best treated with boric acid ointment, and when they are very irritable, a solution of nitrate of silver may be applied with advantage.

Mortification of portions of the auricle, leading to permanent loss of substance, has been observed in cases of paroxysmal hæmoglobinuria, and is a common symptom of Raynaud's disease.

CHAPTER X.

OTHÆMATOMATA, OR BLOOD-TUMOURS OF THE AURICLE.

THIS term is used to designate tumours of various sizes formed in the auricle, and sometimes in the external meatus, as a result of the subcutaneous escape of blood from the vessels. Two forms are described, viz., traumatic and spontaneous, the former being often associated with other injuries of the auricle, such as rupture of the cartilage; the latter occurring without apparent cause. In rare cases, spontaneous effusion of blood beneath the nasal mucous membrane has been observed in association with spontaneous othæmatomata; and in some instances of the latter character, occurring in lunatics, hæmatoma of the dura mater has been discovered after death. Some authorities do not believe that othæmatoma can be developed in the absence of previous injury.[*]

It was formerly supposed that spontaneous effusion of blood into the tissues of the auricle occurred only among insane patients; but this is by no means the case, though the condition is much more commonly found in these subjects, and more often in men than in women. Dr. Hun[†] reports twenty-four instances, of which twenty-three occurred in males; and it would seem that hæmatoma auris in the subject of brain-disease is a highly unfavourable symptom, and points to an incurable lesion.

It appears, from Dr. Hun's statements, that the idiopathic and traumatic forms of the condition differ considerably from each other. He records a case in which an insane patient, the subject of hæmatoma of one auricle, received on the other a blow from a broom-handle, which caused swelling and ecchymosis, but not hæmatoma. He attributes the spontaneous occurrence of the condition to a twofold cause, viz., cerebral congestion, and centripetal irritation of the system by the emotions. The majority of his patients were the subjects of general paralysis and melancholia, and in these conditions there is a tendency to repeated congestions of the head with consequent dilatation of vessels. Other writers allude to morbid changes in the part as favouring the occurrence of othæmatoma; the most important of these are, softening and degeneration of the cartilage, and atheromatous disease of the vessels, which causes them to become very friable. When these conditions exist, a very slight injury may cause rupture of vessels and effusion of blood. Some authors associate fissures of the cartilage with softening, and state that these conditions are not infrequent in emaciated and cachectic individuals suffering from mental affections. The cartilage, in such cases, breaks up into several layers, inclosing irregular cavities containing mucoid fluid and connective tissue. It is obvious that changes of this kind in the cartilaginous tissue predispose to rupture of blood-vessels, and the formation of blood-tumours, and that in consequence of the fragility of the tissue, the effused blood may rapidly force its way through the separate cartilaginous layers.

---

[*] *Archives of Otology*, vol. xiii. p. 303.

[†] *American Journal of Insanity*, July, 1870.

In connection with the influence of nervous disturbance upon the formation of these tumours, some of Dr. Brown-Séquard's experiments have an important bearing. He found that in guinea-pigs, sections of a restiform body near the calamus scriptorius will produce hæmorrhage under the skin of the ear, to be followed afterwards by gangrene, and that these appearances are most marked on the injured side, and less prominent on the other one. He has also found that section of the sciatic nerve will produce the same results, by reflex action on the medulla, and he is led to believe that disease of the base of the brain, not always causing insanity, is the origin of hæmatoma auris. It would seem that this condition of the ear is not confined to the human subject. Several instances of othæmatoma, occurring (without obvious cause) in cats,* have been placed on record. In one instance, after the swelling subsided, the ear began to shrink, and ultimately formed a puckered irregular mass close to the side of the head.

---

* *British Medical Journal*, 1889, vol. i. pp. 187, 648.

A case in which bilateral hæmatoma of the auricle was caused by direct violence has been recorded by Dr. Randall,* of Philadelphia. A girl aged fifteen, whose ears had been pierced a month previously, had an epileptic fit, to relieve which strong traction had been made on the lobules or on the rings. Each auricle presented a soft fluctuating tumour, of a purplish red colour, at the posterior attachment of the lobule. The larger swelling was about the size of a small chestnut. Incisions gave vent to dark blood, and a normal condition was restored under appropriate treatment.

Symptoms.—The appearance of a spontaneous hæmatoma auris is usually preceded by redness and swelling of the ear and side of the face; but sometimes no premonitory symptom is observable. As a general rule, the tumour shows itself on the external surface of the auricle, and generally in the upper half (Fig. 61), as a roundish, smooth, bluish-red mass, varying in size, tense, and more or less elastic. Similar tumours have occasionally been observed on the posterior surface of the auricle.

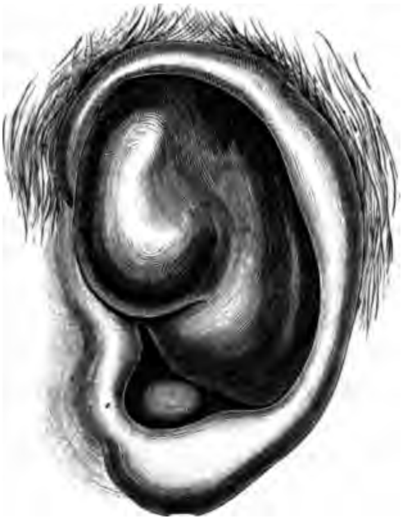


FIG. 61.

SPONTANEOUS OTHÆMATOMA OCCURRING IN AN IDIOT. THE SUPERFICIAL PART OF THE TUMOUR EXCEEDINGLY ELASTIC AND CONTAINING SEVERAL FRAGMENTS OF CARTILAGE, DISCOVERABLE ON EXAMINATION WITH THE FINGER. (*Gruber.*)

---

* *Archives of Otology*, 1894, p. 206.

In some cases the skin is comparatively normal in colour. The ridges of the auricle are obliterated, unless the blood is extravasated into the substance of the cartilage. In the majority of cases, the swelling is developed within a few hours, and remains for some time without change. There may be no subjective symptoms, or the patient may complain of some amount of pain, with a feeling of tension, heat, and tingling. The tumour either bursts spontaneously, or gradually subsides, and undergoes certain changes to be presently noticed.

In traumatic cases, the left ear is more often affected than the right, and the appearances vary with the cause and severity of the injury. As a general rule, the tumour is rapidly developed, inasmuch as it is due to extravasation of blood from vessels ruptured by violence. Fränkel's* experiments, however, show that twenty-four hours or more may elapse before the swelling appears. The site of the extravasation is either between the skin and the perichondrium, or, more rarely, between the latter and the cartilage.

In both classes of cases, the effused blood becomes partially or completely absorbed as time goes on, but more or less deformity is apt to remain, owing to the changes in the cartilage. The contents of the tumour sometimes become mucous or serous in character. In traumatic cases, when the cartilage has been broken and the fragments displaced, the deformity may be very considerable. An auricle, thus deformed, is a distinguishing mark of some old statues of Hercules and Pollux. At the present day, instances of "shrunken ears" in lunatic asylums are far less common than in former times, when there was less supervision over the patients and their attendants. On the other hand, cases are becoming somewhat common among football players. As rare consequences of othæmatoma, little masses of bony tissue become developed in the auricle; chalky deposits are more common. Suppuration is an occasional result, and in one case of traumatic othæmatoma, recorded by Gruber, ulceration and septicæmia ensued.

Treatment.—In spontaneous cases the treatment is very simple. If the tumour be small and not very tense it may be left to subside by itself. Under opposite conditions the fluid should be drawn off with a trocar or evacuated by means of a small incision, and pressure afterwards applied to prevent refilling. In traumatic cases, the relief of pain and the prevention of disfigurement are the objects to be aimed at. The tumour, if tense, should be evacuated, and cold applications used. If coagulation has taken place, it will be necessary to incise the swelling and to remove the clot; cold applications and pressure will constitute the remainder of the treatment, and when all active symptoms have subsided, careful massage will probably aid in restoring the normal condition. If this prove unavailing, pressure should be persevered with, and tincture of iodine should be applied from time to time.

---

* *Archives of Otology*, vol. xiii. p. 303.

CHAPTER XI.

PERICHONDRITIS OF THE AURICLE.

INFLAMMATION of the fibrous membrane covering the cartilage of the auricle gives rise to symptoms more or less resembling those of othæmatoma. The upper part of the auricle is the portion mainly affected, whereas the lobule generally escapes. The prominent symptom is the formation of one or more roundish swellings, which are more or less hot and painful. Considerable deformity is apt to remain after their subsidence. Perichondritis of the auricle is of rare occurrence.

Symptoms and Progress.—In some cases the inflammation supervenes without any obvious cause, and is confined to the perichondrium and cartilage of the auricle. In others, the inflammatory process extends from the meatus, which may be the seat of furuncle, or from the middle ear. In the former case, sharp, shooting, or continuous pain, and a sensation of heat may be the first symptoms, and may continue for several days in the absence of any visible change. Redness and swelling then commence in a circumscribed spot, and gradually become more marked. Fluctuation is soon manifest, and the swelling may continue to increase until it involves more or less of the concavity of the auricle, and encroaches upon or even closes the meatus. The surface of the tumour is pale red in colour and uneven, but the natural elevations and depressions of the auricle are obliterated. In slight cases the symptoms pass off after the swelling has been incised; but in the absence of treatment the skin gives way at one or more points, and a quantity of viscid serous fluid escapes. The discharge subsequently becomes purulent, and fistulous openings are likely to remain. If the perichondrium be detached over a large area, the nutrition of the cartilage will become much impaired; suppuration may extend over the greater part of the auricle, and even to the retromaxillary fossa. The subsequent course is apt to be very tedious; several months may elapse before recovery takes place. In one recorded case,* the swelling involved various portions of the auricle in succession, and caused so much deformity that no part could be recognised. Tuberosities took the places of the fossæ, and the auricle appeared like a lump of flesh. The amount of resulting deformity varies with the degree of the inflammation. In rare cases, portions of the cartilage become necrosed and detached; in others, considerable contraction of the meatus is superadded to the deformity. Ossification of the cartilage is an occasional result.† The posterior surface of the auricle is sometimes involved, and when this is the case large abscesses may be formed. The most severe forms of perichondritis of the auricle occur in neglected cases of middle-ear suppuration, accompanied by abscesses in the meatus.

Treatment.—In the early stage, cold applications may be tried, with the view of checking the inflammatory process. When fluctuation is perceptible, it is best to make a free incision through the tumour, and to scrape away the contents with a sharp curette.‡ Any sinuses that may have formed should be carefully slit up, and granulation tissue should be scraped away, all cavities being afterwards thoroughly cleansed with an antiseptic lotion. Provision must be made for thorough drainage, and iodol or alembroth gauze, covered with cotton-wool and a bandage, forms a good subsequent dressing. In later stages, when much deformity has resulted, improvement may sometimes be effected by removing hardened and prominent pieces of cartilage, and readjusting isolated portions. In a case thus treated by Dr. Knapp, the deformity was greatly diminished. The anatomical examination of the portions removed showed that they contained well-developed true osseous substance.

---

* *Archives of Otology*, vol. xix. p. 8.

† *Ibid.*, vol. xix. p. 45.

‡ *Ibid.*, vol. xix. p. 20.

CHAPTER XII.

HERPES OF THE AURICLE—ECZEMA OF THE AURICLE.

THE auricle is occasionally the seat of herpetic eruptions, which may show themselves on this part alone, or on the face and neck at the same time.

Causes.—Inflammatory processes in the deeper structures of the ear are sometimes attended by herpetic eruptions on the auricle. In the absence of any such causes, the complaint is usually attributed to disordered digestion or to chills; it is commonly seen in adults, but children are not exempt from it.

Symptoms.—The appearance of the vesicles is generally preceded by more or less fever, and local pain of a severe stinging or burning character, the latter symptom being especially troublesome when the eruption extends into the meatus. The pain may exist for several days before any local signs appear. The distribution of the vesicles is sometimes connected with that of the nerves supplying the part (herpes zoster), and the complaint may then be regarded as a symptom of neuritis. The nerves especially implicated are the branches of the great auricular from the cervical plexus, and those of the auriculo-temporal branch of the fifth. When this latter nerve is affected, the eruption, as is generally the case, appears on the external surface of the auricle and the anterior margin of the meatus; the branches of the great auricular are distributed to the internal surface and to the meatus. In rare cases, the eruption appears on the convex surface of the auricle and over the mastoid region.

The appearances are those of herpes elsewhere; small red patches are first noticed, and these become studded over with papules, which are speedily converted into vesicles, closely set and sometimes confluent, so as to form bullæ. The meatus may thus be completely occluded, and sometimes the membrana tympani is likewise the seat of eruption. The contents of the vesicles are at first limpid and pale, but subsequently become opaque and yellow. After a few days either the vesicles dry up and form scabs, which fall off, leaving a reddened surface, or little ulcers result. When the meatus is affected, there may be profuse discharge from such breaches of surface. In some patients there is more or less deafness and tinnitus during the course of the complaint, which is occasionally prolonged by the appearance of successive crops of the eruption.

Treatment.—In the early stages, the general health of the patient is likely to require attention; purgatives and tonics are generally indicated. Severe pain may be relieved by cold applications, or by painting the part over with a mixture of extract of belladonna and glycerine. When vesicles have formed, they should be protected from injury; powdered starch may be dusted over them, and cotton-wool subsequently applied. When suppuration has occurred, the pustules may be opened with advantage; but care should be taken to preserve the epidermis. Any ulcers that may form should be dressed with boric acid ointment or powdered iodol; and when the meatus is the seat of the complaint, and there is more or less discharge, powdered boric acid should be used by means of an insufflator.

Eczema of the Auricle and Meatus.—This is a somewhat common affection, and owing to the anatomical structure of the parts, the complaint is in some respects different from eczema in other portions of the body. It is, moreover, liable to produce more or less impairment of hearing. It occurs in two forms, acute and chronic. Children and young girls are most often affected.

Causes.—An eruption of eczema on the auricle is frequently associated with disorders of menstruation, and occasionally with the climacteric period; in some cases there are evidences of tuberculosis, rickets, or of general malnutrition. The exciting cause is often obscure; but the influence of local irritation is sometimes traceable. Thus exposure to the sun's rays and to the heat of furnaces, warm fomentations, and frictions with various stimulating ointments or liniments, are liable to produce an eruption. A somewhat more common cause is the irritation produced by the discharges in cases of otorrhœa, and the scratching practised to relieve the uncomfortable sensations. The eruption is most liable to occur, and to prove very obstinate, when the otorrhœa is associated with caries of the tympanic walls; it is, in all probability, due to the organisms contained in the discharges. The spread of the eczema may be explained in a similar manner. Dr. Rohrer, of Zurich, inoculated rabbits' ears with cultivations of diplococci obtained from the serum of the vesicles of eczema, and produced a similar eruption. The conversion of the vesicles into pustules is associated with the development of staphylococci. Gruber states that eczema of the ear is sometimes due to irritating matters (dyes, &c.) contained in scarves used to cover the part. Politzer alludes to cases in which circumscribed eczema, on the upper part of the crest of the helix, and occurring symmetrically in both ears, was apparently caused by sleeping on hard horsehair pillows. Eczema sometimes occurs in an epidemic form among school-children, and is possibly due to contagion.

Symptoms.—Acute eczema of the ear gives rise to sensations of tension, itching, and burning in the part, and in children the eruption is commonly attended with fever and restlessness. Complete or partial occlusion of the meatus by the eruption will diminish the hearing-power, and cause tinnitus and other abnormal sensations. The eruption may occur on both surfaces of the auricle; it is most often seen in the fossæ of the upper half of the outer surface, in the neighbourhood of the lobule, and in the angle between the ear and the head. Both ears are generally affected.

The appearances resemble those of eczema on other parts of the body. There is redness and swelling of the skin, followed by the formation of closely-set vesicles, which are apt to burst and leave raw surfaces. These latter become covered with crusts, beneath which a viscid or purulent fluid is secreted. In time the crusts fall off, leaving either a dry surface or small fissures and ulcers, covered with purulent secretion. In slight cases, the process sooner comes to an end; the vesicles dry up, and desquamation takes place.

When the meatus is the seat of the eruption, the epidermis soon becomes detached, the cutis is more or less infiltrated and swollen, and a discharge of turbid serous fluid is a common symptom. The appearances then resemble those of diffuse inflammation of the meatus; but the eruption on the auricle will serve to indicate the real nature of the case.

Acute eczema generally subsides under proper treatment; but the duration of the complaint varies from a few days to several weeks, and the eruption is very prone to recur and to break out on fresh portions of the auricle. After repeated attacks, the condition is apt to pass into a chronic stage, accompanied by thickening of the part and other changes. The subcutaneous connective tissue becomes much hypertrophied, and the auricle is enlarged and rigid, while the meatus is lessened in calibre, owing to the thickening of its walls. The surface is covered with crusts or scales, or both forms may be combined. In the scaly form, the auricle is enlarged and reddened, and is the seat of continuous desquamation. In mild cases, the eruption is confined to portions of the auricle; but in severe forms it extends over the entire ear, and to the face, scalp, and neck, as well as into the meatus. Fissures are very liable to form in the normal grooves and depressions, and especially behind the ear. The itching is generally very troublesome, and patients not infrequently injure the part in their efforts to relieve the uncomfortable sensation. Noises in the ear, arising from the same causes as in the acute form, are often complained of, and hearing may also be impaired as a result of congestion of the Eustachian tube and tympanum.

Chronic eczema of the auricle is often very obstinate. Proper treatment will generally cause improvement or recovery; but relapses are very prone to occur.

There is no strict line of demarcation to be drawn between the acute and chronic forms; the former often run into the latter, and cases sometimes occur which are best described as subacute. Thus, in young children of a tuberculous habit, we often see crusty and impetiginous eczema involving the posterior surface of the auricle, and the hollow of the concha, and forming part of a widely-spread eruption affecting the head and face. These forms of eczema are distinguished by the copious production of scabs and crusts, attached to a much-reddened and inflamed base. The intense itching causes children to scratch the part freely, and ugly bleeding sores are thus produced. Febrile symptoms are often marked, and the absorption of the purulent secretions causes swelling and sometimes abscess in the adjacent glands.

The Diagnosis of eczema of the ear is for the most part easy.

Rare cases of seborrhœa resemble the scaly form, but differ in not presenting any redness and infiltration.

The **Prognosis** varies with the nature of the case. The most obstinate forms are those which are associated with constitutional conditions.

Treatment.—In dealing with a case of eczema, the general condition of the patient almost invariably requires attention. If there be evidences of anæmia, good food, and some preparation of iron are, of course, indicated, and arsenic is generally advantageous in these cases. In tuberculous subjects, good diet, cod-liver oil, and the syrup of the iodide of iron will aid the action of local remedies. For dyspeptic and gouty subjects alkaline purgatives are generally suitable, and the diet and mode of living should be properly regulated. In most cases of chronic eczema, and especially when relapses are frequent, a course of arsenic will prove beneficial.

The *local* treatment of eczema affecting the ear varies with the stage of the complaint. In acute eczema the auricle should be carefully protected from irritation; it should be neither washed nor syringed, but kept well anointed with vinolia, or, failing that, with vaseline or other emollient ointment. If there be much inflammation, the solution of liquor plumbi subacetatis applied on lint may replace the ointment; and for the relief of pain the part may be painted over with a 2 to 5 per cent. solution of cocaine. Another remedy for this stage of the affection is ichthyol dissolved in alcohol (1 part to 50), or made into an ointment with vaseline (1 to 10).

When the stage of crust-formation has been reached, the scabs must be removed in order to allow remedies to act on the affected part. They should be first softened by the application of glycerine or almond oil, and then gently detached. After their removal, and without irritating the skin any further, the auricle should be painted over with some medicated ointment, and pieces of linen or lint smeared over with the same ointment are then to be carefully applied and kept in close contact with the affected part. A large number of preparations are useful for the purpose, and may, if necessary, be tried in succession until a good result is obtained. The ointments of zinc and of boric acid are frequently used; the Germans recommend Hebra's diachylon ointment, composed of equal parts of diachylon plaster and olive oil. Whichever ointment be selected, the lint bearing it should be closely fitted to the depressions on the auricle, and a small plug must be introduced into the meatus. The dressings should be changed at least twice every twenty-four hours, and water must not be used for cleansing the part, but this should be effected by means of cotton-wool and a little olive oil. Salicylic acid is another remedy which yields good results in these cases of eczema, both in the impetiginous and scaly forms, and when the part is covered with crusts. One part of the acid is mixed with ten parts of soap plaster; the mixture is spread somewhat thickly on linen, which is to be carefully applied to the irregular surface of the auricle. If, in spite of this treatment, crusts continue to form, the part should be painted over twice a day with balsam of Peru, which tends to check their development.

In favourable cases the crust-formation ceases, the discharge lessens, and the auricle assumes a more healthy appearance. In this stage it should be carefully protected from irritation of all kinds; washing is to be prohibited, and cleansing must be done with cotton-wool, after which vaseline or boric acid ointment is to be applied.

In the scaly form of eczema, the treatment depends upon the degree of the affection and the amount of infiltration into the subcutaneous tissue. For slight cases, the white precipitate ointment is a good application, and if this fail recourse may be had to boric acid ointment, or to a solution of boric acid in alcohol—1 to 20. Dr. Knapp* recommends an ointment of the yellow oxide of mercury (1 to 2 per cent.) and vaseline, and that the parts should be covered with absorbent cotton as a protection from wind and cold. In more severe forms, with thickening of the epidermis and infiltration of the cuticle and subcutaneous tissues, more active remedies will be required. The part may be covered with salicylic soap plaster, which will tend to soften the indurated parts, and will remove the thickened epidermis. Salicylic acid may likewise be applied as a pigment, two drachms in powder being mixed with one drachm of carbolic acid and ten of glycerine.

Preparations of various kinds of tar are often useful in eczema. The Oleum Cadinum (*Huile de Cade*) and the Oleum Rusci Pyroligneum are generally used. In severe cases, one of these is applied on a stiff brush several times daily, and the part is then dusted over with powdered starch. When the skin becomes softer and paler, the same remedies may be applied as ointments, diluted with vaseline in various proportions. Zinc ointment and an ointment composed of ichthyol one part to ten parts of lanoline are sometimes efficacious. The oleate of zinc, combined with equal parts of vaseline, is said to be preferable to ordinary zinc ointment, inasmuch as it does not coat the surface with a crust of débris, which checks healing, and irritates the part on removal. If these remedies fail, carbolic acid ointment may be tried (1 to 20 of vaseline, with a little glycerine), or a solution may be used composed as follows: acid carbolic, 10 parts; alcohol and glycerine, of each 50 parts, and 250 parts of water.

---

* *Archives of Otology*, vol. xi. page 201.

When the external meatus is the seat of an eczematous eruption, it must be kept free from accumulation of débris, but adherent epithelial crusts must not be forcibly removed by syringing, which would act as an irritant. Gruber recommends that such crusts should first be softened by applying a solution of carbonate of potash in glycerine (1 to 150); the ear may then be carefully syringed. The same author recommends sulphate of zinc for mild cases, without pain; it may be dissolved in glycerine —5 grains to the ounce—and of this, 10 or 15 drops warmed are placed in the ear twice or three times a day. In obstinate cases a solution of nitrate of silver, in spirit of nitrous ether—8 grains to the ounce—should be painted over the surface, and this may be repeated from time to time after the blackened epithelial scales fall off. When much swelling exists, and the canal of the meatus is considerably obstructed, a small pledget of lint smeared over with one or other of the above-mentioned ointments should be placed in it, so as to exert some pressure upon its walls. In more marked cases, it may be necessary to use tents of sponge or of laminaria in order to restore the normal calibre of the part.

In most cases of eczema it is necessary to try several remedies before a good result is obtained, and the list of those at the command of the practitioner is somewhat lengthy. After the eruption has disappeared, and the parts have assumed their normal condition, it is desirable to guard against relapses by persevering with some mild form of treatment. The white precipitate ointment is one of the best remedies available for this purpose.

CHAPTER XIII.

CIRCUMSCRIBED OR FURUNCULAR INFLAMMATION OF THE EXTERNAL MEATUS.

In this complaint the inflammation is limited to one or more spots, and leads to the formation of abscesses or boils. Cases of this kind are somewhat common, their frequency being due to the number of glandular structures contained in the meatus, the cartilaginous portion of which is most liable to be thus attacked. The disorder is more common in adults than in children, and is usually limited to one ear, the left being more often affected than the right. Recurrences, especially during the spring and autumn, are noticed in a large proportion of cases; epidemics of the complaint have been observed in Paris and in Vienna.

Causes.—The complaint sometimes occurs in persons apparently healthy; but in the majority of cases there is likewise some disorder of the general health. Sometimes there are indications of plethora, but signs of impaired nutrition, debility, and anæmia are much more common. Furuncular eruptions in other parts not infrequently coexist; in some cases an eruption of eczema in the meatus has preceded the inflammation. Exposure to cold, mechanical irritation, and the application of remedies to the meatus are occasionally followed by the development of furuncles. Chronic suppuration of the middle ear is another, and a more common cause, the irritation being probably due to the micro-organisms contained in the discharges. Some authorities are of opinion that in cases in which no other affection is present, furuncular inflammation of the meatus is almost always due to pyogenic bacteria. Löwenberg* was the first to demonstrate the presence of such organisms in the pus from aural furuncles, and his observations have been confirmed by subsequent investigators. According to his view when a furuncle has once been formed by an accidental accumulation of specific micrococci in a gland-follicle, relapses and extension are brought about by propagation of the microbes on the surface to other follicles, thus producing new furuncles by auto-contagion. Only the worst cases of furuncles must be explained by the circulation of micrococci in the blood. Kirchner states that he has often discovered the staphylococcus pyogenes aureus in the pus of these furuncles, and has produced abscesses in animals by inoculating them with the cultivated products. Other experiments prove that infection may take place when the skin is perfectly sound, provided that the fluid containing the micro-organisms be applied to it with the aid of friction. Microscopic investigation then shows that the organisms have passed into the hair-follicles. It is, however, difficult to account for those cases in which the application of such remedies as chloroform, æther, and solutions of carbolic acid to the meatus is followed by furuncular inflammation. Cases in which the disorder is probably due to direct contact with decomposing materials are seen among butchers and horse-slaughterers, and persons employed in dressing hides. In diabetic patients, the meatus is occasionally the seat of furuncles, and this part may be affected when boils follow the administration of bromide of potassium. The connection between diabetes and furuncles is, in some measure, explained by the fact that sugar is a favourable medium for the development of pyogenic micro-organisms.

---

* *Archives of Otology*, vol. xi. page 273.

Symptoms.—The anterior and the inferior walls of the meatus and the inner surface of the tragus are the parts most often affected. There is at first more or less diffused redness and swelling, which soon become more marked and defined, so that the meatus is to some extent obstructed. In some cases, two or more such swellings exist at the same time. The tragus is often much swollen, and enlarged glands may be detected below the lobule. The abscess pursues the ordinary course; after a few days the swelling becomes softer, and evidences of suppuration are apparent. If left to itself, the abscess breaks, and fragments of necrosed connective tissue escape with the pus and blood. Healing is sometimes retarded by the formation of ulcers or granulations; but usually the abscess closes in the ordinary way. The inflammation is apt to spread to the adjacent parts; the parotid and neighbouring lymphatic glands sometimes become swollen and painful, and the tissues covering the mastoid process may be similarly affected, especially when the abscess is situated on the posterior wall of the meatus. More or less œdema of the side of the face and neck is sometimes present. Should the inflammation spread to the tissues connecting the auricle with the skull, the former will project from the side of the head.

The **Subjective Symptoms** are such as might be expected from the nature and seat of the complaint. Pain is always more or less severe, and is apt to be accompanied by febrile symptoms, especially if the deeper parts of the meatus be involved. The pain increases with the progress of the inflammation, and often extends for some distance around the ear. It is aggravated by movements of the jaw, as in speaking and eating, and by touching the auricle; it is always worse at night. In children, high fever may be accompanied by vomiting and delirium, so that the symptoms resemble those of meningitis.

Escape of the contents of the abscess is followed by marked relief of all the symptoms, and, unless other swellings form, the pain rapidly subsides, and is succeeded by a feeling of fulness and itching, which soon passes off. For some days, however, movement of the jaw may be more or less painful.

While the abscess is forming, deafness is generally present, though the patient may not be aware of any difference, unless the meatus be completely occluded. When the deep part of the canal is affected, the deafness may be due to implication of the membrana tympani. Noises in the ears and sensations of pressure and fulness are often complained of. These symptoms are due to hyperæmia and increase of pressure in the labyrinth, and they subside after the abscess has burst or been opened. When the inflammation involves the more external portion of the canal, the subjective symptoms may be very slight or altogether absent.

In exceptional cases the abscess, instead of healing up, continues to discharge for some time. According to Prof. Gruber, this peculiarity is due mainly to the position of the abscess. Prolonged suppuration is more liable to occur in certain parts of the auditory canal than in others, and increased vascularity would seem to account for the difference. Thus when the upper wall is affected, the processes are peculiarly severe and obstinate. In this part the vessels are larger and more abundant than elsewhere, and the tympanico-squamous fissures likewise favour the spread of inflammation. The general health of the patient may considerably influence the healing process. In cachectic subjects, the abscess not infrequently continues to discharge a thin serous fluid, which is found to be connected with the development of granulations or polypoid growths. In such cases, several abscesses are apt to form in succession, causing much pain and distress to the patient.

As a general rule, the consequences of furuncular inflammation of the meatus are confined to the canal itself, but the mischief sometimes spreads to the surrounding bones and to the contents of the cranium. Extension to the parotid may easily take place through the clefts in the cartilage, and if, as sometimes happens, fissures exist in the upper and posterior walls, the inflammation might spread to the base of the brain and to the mastoid cells.

Diagnosis.—There is seldom any difficulty in distinguishing an acute abscess from other affections of the meatus; it is only in exceptional cases that any mistake is possible. Of the tumours with which abscesses may be confounded, only one, viz., exostosis, originates in the meatus, while others starting from other parts sometimes protrude into the canal. In exostosis, the tumour is hard and resistant, but slightly tender on being touched, does not present signs of inflammation, and its appearance never rapidly changes.

With regard to tumours projecting into the meatus, polypi occasionally more or less resemble abscesses, inasmuch as they sometimes form tense, smooth, and shining tumours. Their mode of growth is, however, very different, being painless and comparatively slow; a probe can be passed round a polypus and between it and the wall of the meatus, and, if the swelling be pricked, it will discharge only a little blood and will not diminish in size. If the polypus contains cysts, these, of course, will collapse when pricked, but the discharge will be thin and watery.

Purulent collections finding their way into the meatus from other parts far more closely resemble abscess of the meatus itself. Thus, abscess of the parotid gland may extend through the clefts in the cartilage, or through the line of union between this and the bone, and appear as a swelling in the walls of the meatus. The nature of the case will, however, appear from its history and symptoms; in parotid abscess, there will be marked swelling in front of the ear, and the tumour in the meatus will increase in size when pressure is made on that part. The quantity of pus discharged will be greater than in abscess of the meatus, and pressure on the parotid region will increase the flow. Pus may likewise find its way through the posterior wall, and, in this case, from the mastoid cells; but there will be no difficulty in distinguishing such cases. The pain, redness, and swelling over the mastoid process, the symptoms of suppuration within the tympanum, and the history and progress of the case will indicate the source of the mischief.

Prognosis.—Furuncular inflammation is rarely a serious complaint, and generally ends in recovery. Relapses are, however, very common, and in debilitated persons the pain and discharge will tend still further to reduce the strength. If the inflammation extend to adjacent parts, and especially to the mastoid cells or the dura mater, the prognosis will become grave.

Treatment.—If the case be seen in the early stage, an attempt may be made to cut short the inflammation; it is, however, rarely successful. Cold may be applied to the parts by means of Leiter's apparatus, and in plethoric subjects purgatives and low diet are generally advantageous. Two or three leeches may be tried, applied in front of the ear, or over the mastoid process; but their application, though it may lessen the pain, rarely checks the progress of the inflammation. The author has found the following ointment serviceable:

℞. Hydrarg. Perchlor. . . .	. gr. $\frac{1}{16}$
Ext. Belladonnæ	. ʒi.
Aq. Destil.	. ♏x.
Glycerin.	ad ʒij. Misce.

It should be applied several times a day and the meatus syringed out with a warm solution of biniodide of mercury, 1 in 2,000, before each application. Gruber[*] recommends the introduction into the ear of conical plugs of gelatine, containing about the sixth of a grain of extract of opium, or half the quantity of hydrochlorate of morphine. These preparations are used as follows: the external meatus is carefully cleansed with a warm 4 per cent. solution of carbolic acid, the "aural ovoid" is then introduced into the ear with a pair of forceps, and retained in position with a little cotton-wool. The gelatine rapidly dissolves and acts as an antiphlogistic, while the morphine relieves the pain. The application is to be renewed, according to the symptoms, from once to three or even four times a day, and when improvement has taken place, half the quantity may prove sufficient. Dr. Gruber states that since he has made use of these preparations, he has witnessed excellent results, and has rarely had recourse to scarification, a method which he formerly recommended.*

---

[*] *Lehrbuch der Ohrenheilkunde*, II. Aufl. S. 292.

When there are only a few furuncles or the area affected is small, the pain may be relieved by slightly puncturing the swollen tissues, but if there is a considerable amount of inflammation it may be desirable to make a free incision to relieve tension. When pus has obviously formed, a free incision is the proper treatment, and bleeding should be encouraged by pouring warm water into the ear. A knife, resembling that used for tenotomy, is the best instrument for making the incision, which should extend down to the bone or cartilage. After the operation the wound should be painted over with carbolised glycerine or solution of boric acid, and then it is well to insert a small pledget of moistened lint, or antiseptic gauze, but not so thick as to cause pain. The dressing should be renewed several times a day, and the meatus syringed out with a warm disinfectant solution on each occasion. As a general rule, the suppuration soon ceases, the swelling passes off, and the wound heals in a few days. The boric acid solution may be applied several times daily until cicatrisation is complete.

If the case be considered as not quite ready for incision, attempts should be made to hasten the suppuration, and at the same time to relieve the pain. When the abscess is situated in the deeper part of the meatus, both indications may be fulfilled by instilling from time to time warm decoction of poppies, to which a little laudanum has been added. The fluid should be dropped into the ear every half-hour, and allowed to remain for several minutes, when the meatus should be plugged with cotton-wool. Continuous irrigation of the meatus with hot water by means of a siphon often gives considerable relief. For abscesses involving the cartilaginous portion, plugs of cotton-wool, saturated with a warm solution of the acetates of lead and of morphine, are the best applications. The exposure of the ear to steam and the use of warm poultices to the auricle are to be deprecated; the latter is apt to cause inflammation of the parotid gland and periostitis of the mastoid process. For the relief of violent pain, recourse may be had to a morphine ointment, 1 to 50 of vaseline, and the same remedy may be given internally or injected subcutaneously. Politzer recommends the introduction into the meatus of a longish piece of lard covered with morphine and boric acid ointment (boric acid, gr. 15; vaseline, gr. 300; morph. acet., gr. 3). The same author points out that antiseptic treatment is of great value in dealing with furunculosis of the external meatus. Repeated eruptions are not uncommon, and are doubtless due to bacteria. The best remedies are carbolic acid mixed with glycerine (1 part to 30) applied with a brush, and boric acid in powder or in an alcoholic solution; these remedies may be used both before and after the abscess has burst or been opened. Löwenberg recommends boric acid in aqueous or alcoholic solutions, both before and after the escape of pus. It is well, indeed, to persevere with the antiseptic treatment after incision and until the wound is healed: the subsequent development of furuncles is thus checked. In obstinate cases, with frequent relapses, a solution of perchloride of mercury in alcohol (1 to 1,000) may be dropped into the ear thrice a day, and a warm solution of calcium sulphide (1 per cent.) has likewise been recommended. Even should there be no second abscess, an irritable state of the meatus often continues for some time. For this condition, white precipitate ointment is a very good application. Granulations and polypoid excrescences are best treated by the careful removal of secretion and touching them with a solution of chromic acid, and afterwards insufflating powdered boric acid into the meatus several times a day. In obstinate cases the instillation of alcohol is often beneficial. As in most cases of furuncular inflammation of the meatus, the general health is impaired, tonics and other suitable constitutional remedies must not be omitted. When the patient is suffering from chronic suppuration of the middle ear, every effort should be made to induce a healthy condition of the tympanic mucous membrane. The methods of treatment will be described in a subsequent chapter.

---

* These "aural ovoids" can now be obtained from Messrs. Bullock & Co., of Hanover Street, Regent Street. (See note on page 242 of the translation of Dr. Gruber's work.)

CHAPTER XIV.

DIFFUSE INFLAMMATION OF THE EXTERNAL AUDITORY MEATUS.

THIS affection occurs in two main forms: in the first, the inflammation involves only the superficial layers of the cutis, with desquamation as a result. In the second form, the various layers of the soft parts lining the meatus are uniformly affected, the inflammation being of the phlegmonous character, and presenting the ordinary symptoms. The process extends over more or less of the meatus, and generally involves the membrana tympani and the tympanum itself.

Causes.—Diffuse inflammation of the meatus is somewhat more common in children than in adults; it seldom occurs as an idiopathic affection. It most often follows upon inflammatory diseases of the middle ear attended with perforation of the membrane. Minute perforations of Shrapnell's membrane, which are very apt to be overlooked, are often the cause of a *supposed* uncomplicated external otitis. On the other hand, the complaint is sometimes witnessed (as a result of extension from the surface) in the course of scarlet fever, measles, and small-pox. Severe eczema of the meatus, especially if the part be irritated, may lead to diffuse inflammation. The presence of foreign bodies, injuries, burns, accumulations of cerumen, and chemical irritants, are less frequent causes. A peculiar form of the complaint is due to the presence of fungi. When associated with purulent inflammation of the middle ear, it is probably due to the micro-organisms contained in the discharges; but, owing to the presence of the bacteria of decomposition, the secretion may be fœtid in the absence of middle ear disease. An attack of diffuse inflammation sometimes results from the entrance of cold water during bathing. Syphilis is an occasional cause, and an abscess is sometimes the starting-point of diffused inflammation, which may extend over the entire meatus. Cases due to diphtheria will be described in a subsequent chapter.

Symptoms.—These are generally more severe than in the circumscribed form. In acute cases the patients complain of intense pain, deafness and noises in the ears; and more or less fever generally accompanies these symptoms. If the inflammation be of a superficial character, on examining the ear the meatus will be found to be reddened and somewhat swollen, and its surface covered with scales of desquamated epidermis. In the phlegmonous form, the osseous portion of the canal is most often affected, and the redness and swelling are very marked. The membrana tympani is likewise implicated, and if the parts will permit the introduction of a speculum, it is seen to be dull and hyperæmic, especially at the periphery and along the handle of the malleus. Its boundary is also indistinct, in consequence of the swelling of the walls of the meatus. Abscess may form in the membrane, and cause perforation and inflammation in the tympanum. As the case proceeds, the appearances vary according as the deeper or the more superficial parts are involved. When the latter are mainly affected, in the course of a few days more or less secretion escapes from the meatus, the fluid being at first serous and tinged with blood, and afterwards purulent. Its odour, which is generally very marked and disagreeable, is due to the presence of saprophytic bacilli. When the deeper parts are affected, there is a diffused swelling, more or less hard and red, not always uniform, but generally more prominent in some parts than in others.

When the inflammation has commenced in the osseous portion of the meatus, it generally extends to the periosteum and to the connective tissue of the cartilaginous part. The integument over the mastoid process and the parotid and neighbouring lymphatic glands is apt to become swollen and painful. The subsequent course of the complaint depends mainly on the causes to which the inflammation was due. External otitis, set up by foreign bodies or other irritants, generally subsides under proper treatment; but, in other cases, improvements are wont to alternate with relapses, and many weeks may pass before the inflammation really comes to an end. More or less contraction of the canal, due to the thickening of its cutaneous lining, may remain for some time. The constitutional condition of the patient has a marked influence on the course of the inflammation. In tuberculous and debilitated subjects, the swelling is apt to be less marked, the walls of the meatus are relaxed and studded over with granulations, covered with a thin secretion, having an unpleasant odour, and sometimes mixed with blood. The condition is likely to prove obstinate, and fails to subside until proper attention is paid to the general condition.

There is a rare form of the disease which is characterised by the appearance of hæmorrhagic vesicles on the walls of the osseous portion of the canal (otitis externa hæmorrhagica). According to Dr. Gorham Bacon,* this form occurs usually without any known cause in young persons, and commences with moderate pain, tinnitus, and slight deafness. On examination, the vesicles appear as dark blue elongated swellings in the osseous meatus, generally on the inferior, more rarely on its posterior wall; they often extend inwards to the membrana tympani and outwards to the cartilaginous meatus, and block up the canal to a greater or less extent. The condition is that of superficial inflammation of the cutis, the epidermis being raised by the hæmorrhagic exudation. The swelling is soft and yielding, and is easily punctured; the fluid that escapes is more or less tinged with blood. When left to itself, either the vesicle gives way, or its contents become absorbed, the process being completed in from eight to fourteen days. Males are more often affected than females, and the left meatus is more frequently involved than the right. The pain is seldom severe. Dr. Swain† has recorded five cases of this character, more or less closely associated with attacks of influenza. The vesicles may be very rapidly formed, as in a case recorded by Dr. Dunn.‡ Pain had lasted for only a few hours when a reddish fluid escaped from the ear. There were signs of extravasation of blood in the skin of the osseous meatus.

The most frequent result of diffuse external otitis is a return to the normal condition, but for some time before this is established there may be increased formation and detachment of epidermis, or increased secretion of cerumen. Inasmuch as the membrana tympani is often implicated, perforation is not uncommon. Sometimes the complaint passes from the acute to the chronic form; the pain and fever subside, while the discharge continues in increased quantity, and such consequences as hypertrophy of the cutis, granulations, and bony growths in the meatus, more or less occluding the canal, may become developed in the course of time. Syphilitic and diphtheritic inflammation may result in extensive destruction of the soft parts and of the osseous walls, with consequences dangerous to life; in less severe cases, adhesions and contractions of the canal are sometimes thus caused.

---

* *Archives of Otology*, vol. xix. p. 1.

† *Ibid.*, vol. xx. p. 197.

‡ *Ibid.*, vol. xxiii. p. 211.

Diagnosis.—Diffuse inflammation of the external meatus can in most cases be easily distinguished from other affections of this part; but when the canal is much swollen, it may be impossible to introduce a speculum, so as to obtain a view of the deeper portion and of the tympanic membrane. In such a case, information as to the cause can be obtained only from the previous history, and for some time the surgeon may be in doubt whether the inflammation is of local origin or whether it is due to middle ear disease.

The **Prognosis** of diffuse external otitis is for the most part favourable, and especially if the complaint be confined to the soft parts of the canal. If, however, the bone be implicated, or if the mischief spread to the membrana tympani and tympanum, the consequences may be very serious, though they may not be exhibited until long after the disease in the meatus has quite subsided. The inflammation has been known to extend through the superior and posterior wall of the osseous meatus to the mastoid cells, and also to the lateral sinus. It may likewise extend upwards to the base of the skull, and produce lesions in the membranes and in the brain itself. The inflammation may extend in yet another direction, viz., forwards to the articulation of the lower jaw, and to the parotid gland. In the former instance, its course is favoured by the existence of a fissure in the osseous wall; and in the latter, by a similar condition in the cartilage. With regard to the condition of the tympanum, it may be impossible to foretell with accuracy the result of perforations or of extensive infiltration in the membrane; though if the perforation be small, and there be no serious constitutional dyscrasia, it may be expected to heal in a few weeks. The same may be said of thickening and infiltration; this condition may subside without impairment of hearing, but in severe cases, and especially if periostitis and other complications be present, the change for the worse is likely to be permanent. In tuberculous, much debilitated children, the prognosis is very unfavourable; destruction of the membrane and permanent loss of hearing are likely to result.

Treatment.—The indications are much the same as in the circumscribed form; the causes of the complaint must be sought for, and removed when possible. If the patient be seen at the commencement, when hyperæmia is very marked, the best plan is to scarify the swelling freely; tension and pain will be thereby much relieved, and the progress of the inflammation may possibly be cut short. When desquamation and a moist condition of the surface are the prominent symptoms, the insufflation of calomel or finely powdered iodoform or iodol will prove efficacious. When the surface becomes dry, an ointment containing 5 per cent. of naphthol forms a good application. If the process has gone on to suppuration, a free incision is urgently indicated, and delay may be attended with very serious local and general results. All stimulating applications must, of course, be avoided in the early stages; warmth may be applied by means of Leiter's apparatus filled with warm water. In the chronic stage attended with free discharge, constitutional treatment is always required. The insufflation of finely powdered boric acid is the best local measure; and if this fail, a few drops of warm rectified spirit may be poured into the meatus. A strong solution of nitrate of silver (20 to 30 grains or more to ℥i.) is another remedy. For the relief of pain, the surface may be painted over with a solution of atropine, using ♏iij. of a 1 per cent. solution.

CHAPTER XV.

CROUPOUS AND DIPHTHERITIC INFLAMMATION OF THE EXTERNAL AUDITORY MEATUS.

Croupous Inflammation of the External Ear is very rarely seen, though Wilde alludes to it, and several cases are reported by German authorities. It is described by Bezold as occurring most often in adults and seldom affecting both ears at the same time. It may be an independent affection, but is usually associated either with furuncles in the meatus or with inflammatory processes in the middle ear. The osseous portion of the meatus and the surface of the membrana tympani are the seat of the exudation, which takes the form of a yellowish-white, soft elastic layer, sometimes marked with streaks of blood. Seen under the microscope, it is found to consist of a fibrous network, containing round cells, nuclei, and epidermic cells. The membrane can be easily detached; the subjacent surface is swollen, injected, and slightly excoriated; fresh exudation may occur from time to time until the whole mass comes away and the process terminates. The progress of the complaint is attended by pain and slight fever, and sometimes by a similar exudation on the tonsils. The meatus is contracted, but hearing is unimpaired; there may be some swelling of the retro-maxillary glands. The *prognosis* is favourable; the complaint comes to an end in the course of a few days, and may be cut short by the insufflation of boric acid.

Diphtheritic Inflammation of the Meatus is attended with marked febrile symptoms and pain of a very violent character. The affected spots are covered with patches of white exudation, which remain for some time firmly adherent, and whose detachment reveals deep ulcers and fissures. A purulent or bloody discharge escapes from the ear, the parts are considerably swollen, and the surrounding structures are in a similar condition. The exudation may be found both on the auricle and in the meatus, or it may be confined to one of these parts; in some cases a similar exudation is found in the throat, nose, and mouth.

Diphtheritic exudation is said not to occur when the cutis is sound, and in most of the cases which have been observed the deposit has been of a secondary character, affecting ears already the seat of ordinary inflammation. The patients are generally tuberculous and debilitated subjects, whose ear-affection has been neglected. In one case the diphtheritic deposit made its appearance after the patient had held her ear over a vessel of hot water, probably impure, for the relief of external otitis. In the course of a few days violent pain, accompanied by fever, was experienced, and when the ear was examined, a white diphtheritic deposit, firmly adherent and bleeding when touched, was detected in the meatus.

The course of the disease varies. Sometimes the exudation is speedily detached; sometimes it remains adherent for many days, and when separation takes place a fresh deposit ensues. After detachment, ulcers may remain for a considerable period, and cause much trouble. In very severe cases gangrene of the soft parts may result from diphtheritis of the meatus. The complication has been observed in institutions in which a case of gangrene had occurred; the patients are usually tuberculous and ill-nourished children. It has also been noticed in an epidemic form. The progress of the local affection is very rapid; the inflammation may be confined to small spots, but it speedily leads to gangrene. More or less extensive sloughs form, extending through the soft parts to the bones, which may also perish, and the destruction has been known to spread to the cheek, forehead, and neck.

The **Diagnosis** of diphtheritis of the external ear depends upon the discovery of the firmly-adherent membrane, attempts to remove which cause much pain and hæmorrhage. The nature of the exudation is placed beyond doubt if the nose or pharynx be the seat of a similar deposit, or if an epidemic of the complaint be raging in the neighbourhood.

The **Prognosis** varies with the general state of the patient; it is favourable if the health be otherwise good, and if the complaint be seen in an early stage. It is unfavourable under opposite conditions, and also if there be similar deposits in the pharynx or nose. In cases in which the throat is affected, the mischief is apt to spread along the Eustachian tube to the middle ear. Such extension is sometimes witnessed in cases of scarlatina, though in that complaint middle ear suppuration more often occurs without a diphtheritic process. When this latter is present, it almost always causes serious changes, not only in the membrana tympani and the ligaments of the ossicles, but in the walls of the cavity. Impairment of hearing is almost certain to occur, even without caries of the labyrinth; it is said to be due to secondary inflammation with small-celled infiltration of the membranous labyrinth.

Treatment.—Antiseptic remedies are to be relied upon for the treatment of diphtheritis of the external ear. When the affection is of a primary character, the meatus should be filled frequently with a warm 5 per cent. solution of papain and syringed out from time to time with a warm solution of biniodide of mercury (1 in 1,000), until the diphtheritic membrane has been destroyed. Iodol should then be blown into the ear. Lime water has been used for promoting the detachment and separation of diphtheritic membrane, and the local application several times daily of solution of the perchloride of iron (1 to 10 glycerine) is also recommended. If relapses occur, the affected parts should be brushed over with carbolised glycerine (1 to 15), or carbolised spirit (1 to 20), and several times a day the meatus should be filled with an alcoholic solution of salicylic acid (1 to 100), or of perchloride of mercury (1 to 1,000). No attempt should be made to remove the false membrane by mechanical means.

CHAPTER XVI.

PARASITIC INFLAMMATION OF THE EXTERNAL MEATUS.

Symptoms of inflammation in the external meatus are occasionally due to the growth and accumulation of certain fungi, of which the *aspergillus niger*, *flavescens*, and *fumigatus*, and the *trichothecium roseum* are the most common. It is only during the last thirty-five years that these parasites have been carefully studied; at first their effects were supposed to be limited to the membrana tympani, but it is now fully recognised that external otitis may be due to their presence. It is, however, true that in their advanced stages of development they are most commonly found on the membrane, and in the adjoining portion of the meatus,

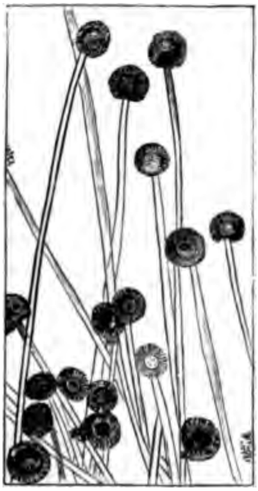


Fig. 62.

Aspergillus Niger: Heads with Conidia. × 600. (*Siebenmann.*)

where they set up superficial inflammation. The fungi are generally mixed with masses of epidermis, cerumen, hairs, and inspissated secretions, the colour of which they modify in various ways. Sometimes they appear in tiny patches, of a black, brown, yellow, greenish, or even reddish tinge. In a case recorded by Dr. Knapp, a cotton pellet, which, moistened with glycerine lotion, had lain for some time at the bottom of the canal, and served as an artificial drum-head, was found covered and pervaded with *aspergillus niger*.

The **Microscopical Appearances** differ according to the kind of the parasite and the stage of its development. In the fully-formed *aspergillus niger*, there is a greyish-white base or mycelium, from which small tubes sprout upwards. These have a double contour, and are sometimes divided transversely; at their unattached ends they present enlargements, or receptacles, consisting of penicillate cells, to which lines of spores are attached. The colour of these spores varies according to the kind of fungus: some are yellowish or reddish; others, black.

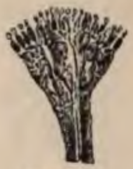


FIG. 63.

ASPERGILLUS NIGER: FOUR SPROUTING STERIGMATA. × 250. (*Siebenmann.*)

Experiments have shown that the presence of these spores is not, *per se*, sufficient to cause inflammation in the healthy ear, but other conditions, either of an individual or local character, appear to be at the same time necessary. Anything which tends to loosen or detach the epidermis assists the action of the fungi upon the cutis: thus, Politzer has recorded a case in which the meatus was filled with aspergilli, but showed no sign of inflammation. He slightly incised the cutis, and after a few days inflammatory infiltration became developed, and required fourteen days for its subsidence. In another case the inflammation was excited by a scratch caused by a speculum.

The cerumen of the ear is said to be an unfavourable medium for the growth of these fungi, and their development is quickly checked by decomposed pus on account of the ammonia which it contains.* Fresh pus has no such effect upon aspergilli, which have been found in the discharge in a case of suppuration of the middle ear. Bezold, however, asserts that the fungus is never found when the suppuration is of recent date. The growth of the fungus is favoured by anything which tends to render the discharge more serous in character, and to prevent decomposition. Hence solutions of tannin and zinc stimulate

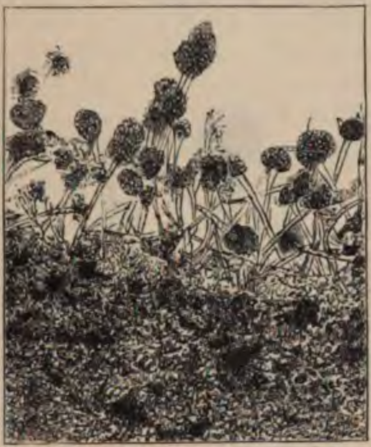


FIG. 64.

ASPERGILLUS FUMIGATUS: HYPHÆ AND ORGANS OF FRUCTIFICATION, CULTURE IN GELATINE. × 60. (*Siebenmann.*)

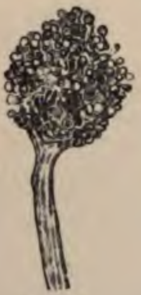


FIG. 65.

ASPERGILLUS FUMIGATUS: TYPICAL SPECIMEN OF HEAD. × 300. (*Siebenmann.*)

---

* F. Siebenmann, *Archives of Otology*, vol. xii. p. 207.

the development of the aspergillus. The spores find a favourable resting-place in the meatus, inasmuch as they are kept at a suitable temperature, and are protected from external and mechanical agencies. Fatty substances (the cerumen being an exception) would appear to favour their growth, and they are said to be most often met with in persons dwelling in damp rooms. Politzer observed a case in a young man employed in the manufacture of yeast. Children are rarely affected; the majority of the patients are middle-aged, and are found to have suffered at some time or other from chronic catarrh of the

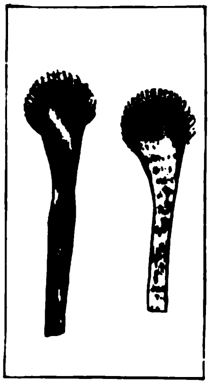


FIG. 66.

ASPERGILLUS FUMIGATUS: SPHERICAL HEADS WITHOUT CONIDIA. × 300. (*Siebenmann.*)

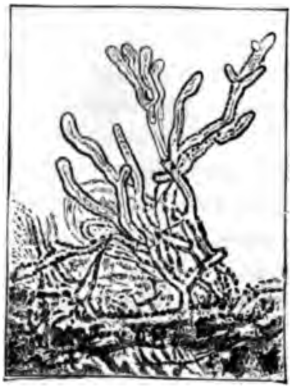


FIG. 67.

ASPERGILLUS FUMIGATUS: MYCELIUM. × 600. (*Siebenmann.*)

tympanum, or from some inflammatory affection of the meatus, for the relief of which oil of some kind has been applied. It would also appear that the mycelia are able to penetrate into the tissues of the membrana tympani. Bezold states that the number of cases of otomycosis has considerably diminished during the last few years ; and he attributes this change to the disuse of oily substances in the local treatment of diseases of the ear.

Symptoms.—Fungi may be present in the meatus without causing any subjective symptoms, and in order for them to set up irritation some loosening or detachment of the epidermis appears to be necessary. Their presence then produces a sensation of fulness, itching, or even pain, noises in the ears, and some amount of deafness. The pain is said to be of a dull, heavy character. The tinnitus and deafness are due in part to pressure on the membrana tympani, and partly to irritation of the more internal portions of the ear. The presence of the fungi usually gives rise to more or less thin serous discharge.

On examining the meatus the fungus-masses are found to occupy the inner third, and to overlay the membrana tympani in the form of a yellowish or whitish layer, from which minute stalks with rounded heads may occasionally be seen to rise. These hair-like projections give a velvety appearance to the mass, and the colour of the surface depends upon the kind of fungus. Sometimes the growths appear in patches over the membrane, and sometimes they are confined to the meatus. The former is the most usual seat of the fully-developed fungi; after their removal, which, in the early stage, is a matter of some difficulty, the spots to which they were attached present a reddened appearance, and are devoid of epidermis. If the redness prove permanent, a re-development of the parasite may be anticipated.

The course of the complaint may be either acute or chronic; if left to itself the parasitic mass becomes fully developed in from one to two weeks. It may then become either partly or entirely detached, but relapses are very apt to take place in the absence of treatment, so that the disorder becomes chronic. In some cases, the fungus-masses are detached from time to time in the form of whitish or brownish casts of the canal. Perforation of the tympanic membrane may result from the inflammation.

Syringing the ear always relieves the pain and other symptoms; but unless proper treatment be superadded, the improvement is only temporary.

Diagnosis.—This can never be difficult if the ear be carefully examined with a speculum. Dark-brown masses of epithelium, dust of various kinds, and especially coal-dust, may line the meatus, and somewhat resemble a fungus-growth. In one instance, tiny fragments of leather derived from a syringe were mistaken for parasites, but in all such cases the microscope will detect their true nature. The addition of a little liquor potassæ with glycerine clears up epithelial fragments, and brings the fungi more clearly into view.

Prognosis.—The prognosis is always favourable, inasmuch as the parasites are easily destroyed by remedies. A tendency to relapse is, however, noticeable, especially in persons living in damp localities. Should the membrane become perforated, the parasites may enter the tympanic cavity and multiply there. Under such circumstances, the complaint may prove very obstinate, on account of the difficulty of applying remedies to the various portions of the tympanum.

Treatment.—This is of a satisfactory character, and the remedy mainly to be relied upon is strong alcohol. The parasitic masses should be removed as far as possible by syringing the ear, or with the forceps, while the ear is well illuminated, and the meatus should then be filled with warm alcohol, which should be allowed to remain for about a quarter of an hour. This treatment should be repeated two or three times a day until the parasite is quite got rid of, and to prevent recurrences the alcohol should be used weekly for several months. If it cause pain it should be diluted with a little water. In very obstinate cases, a solution of perchloride of mercury in alcohol (1 to 500) may be used. This treatment very rarely fails, but, should it do so, other remedies may be tried. Thus, calomel or boric acid finely powdered may be used with an insufflator; or a strong solution of the permanganate of potassium may be poured into the ear. A 10 per cent. solution of nitrate of silver similarly used has proved efficacious. Siebenmann recommends an alcoholic solution of salicylic acid (4 per cent.).

Prophylaxis.—The same authority states that by way of prophylaxis the following rules should be observed:—

All unnecessary applications of fats to the ear, as well as aqueous instillations or injections, should be avoided.

Loss of epidermis and cerumen should be prevented as far as possible.

All secretory processes of the external and middle ear should be carefully treated, dry remedies being the most suitable.

Alcohol kills the fungi and lessens secretion.

All instruments used in removing fungus-membranes should be very carefully disinfected.

CHAPTER XVII.

SYPHILITIC AFFECTIONS OF THE EXTERNAL EAR.

Primary Syphilitic Sores of the auricle and meatus are of very rare occurrence, and only a few cases have been recorded. Professor Lang,* of Innsbruck, mentions two instances; in one of these there were two sores, one on the cheek and the other on the lobule. The patient, a man aged fifty-six, had been infected by using a towel belonging to a son who was suffering from the disease. In another case,† the sore was situated on the tragus and the anterior wall of the meatus, and the infection had been communicated from the lips of a prostitute. Politzer cites two cases, mentioned by other writers.

In the cases above mentioned, the sores presented the usual appearances; the parts behind the ear, the side of the neck, the parotid, and the submaxillary regions were all more or less swollen.

Secondary Syphilitic Manifestations are not infrequently seen on the auricle and external meatus; they take the form of maculæ, papules, condylomata, pustules, or their consequences, such as desquamation, ulcers, and cicatrices. Similar eruptions are always present at the same time on different parts of the body, and especially on the forehead and face. Gummatous growths are rare in the auricle, but they have been known to spread over the entire part, and to cause extensive ulceration and destruction of tissue.‡ The meatus is the occasional seat of condylomata and ulcers, the former being usually associated with similar manifestations in other parts. Confluent condylomata have been noticed on both sides. These growths occur in an early stage of the disorder, and most frequently appear at the bottom of the meatus. The majority of cases occur in women already the subjects of otorrhœa. Red or brownish patches are first seen, becoming gradually raised by infiltration, and developing into condylomata with a more or less uneven surface. These growths may completely occlude the meatus, and be mistaken for polypi. Superficial disintegration results in the formation of ulcers, which after a time cicatrise, sometimes causing contractions in the meatus. The glands in the neighbourhood of the ear are more or less swollen. In a case recorded by Dr. Würdemann,* of Milwaukee, fifteen years were said to have elapsed between the primary disease and the appearance of condylomata in the meatus.

---

* *Vorlesungen über Pathologie und Therapie der Syphilis*, S. 430.

† This case is recorded by Dr. Zucker, of Berlin, *Archives of Otology*, vol. xiii. p. 245.

‡ See a case reported by Mr. Field, *Brit. Med. Journ.*, October 6, 1877.

At first the condylomata may give rise to no marked subjective symptoms; but, during the stage of ulceration, there is generally more or less violent pain in the ear, increased by movements of the lower jaw. Tinnitus aurium and deafness are generally present, being due either to obstruction in the meatus or to extension of the disease to the tympanum; perforation of the membrane has been occasionally noticed. Professor Lang describes a case of papulous infiltration of the membrane, in a woman aged twenty, recently affected. A papular growth as large as a hempseed was found to occupy a portion of the membrane, corresponding with the short process of the malleus; the anterior superior quadrant was of a deep-red colour; the remainder of the membrane was uniformly dull. On the left side the membrane was also cloudy and marked by vascular injection behind the short process. Hearing was much impaired on the right side, but all the symptoms improved under treatment.

The **Diagnosis** of condylomata of the auricle and meatus is for the most part easily made, inasmuch as other signs of the disease are sure to be present in various parts of the body. The genitals, groins, throat, and neck should, of course, be carefully examined. The **Prognosis** is favourable if proper treatment be employed.

---

* *Archives of Otology*, vol. xxi. p. 303.

Gummatous Growths very rarely affect the external when present they may take the form of diffuse infiltration of tubercles about the size of a pea or larger. This form disease of the auricle is one of the later manifestations syphilis. In a case described by Dr. Burnett,* the growt appeared as a circumscribed infiltrated lump on the posterio surface of the auricle, and gradually increased until, in a mont or six weeks, it had diffused itself throughout the greater part of the auricle, and somewhat over the mastoid portion. The infiltration gave rise to thickening and considerable deformity, and after several weeks softening and ulceration took place. The destruction of tissue proceeded at a rate varying with the general condition of the patient; there was no pain, but a copious yellow discharge, with a very offensive odour. A few similar cases have been recorded by Dr. A. H. Buck, Politzer, Hessler,† and others.

The **Diagnosis** of gummatous ulceration may present some difficulties, unless signs of syphilitic disease are discovered in other parts, such as the throat, skin, or bones. It is distinguishable from epithelioma by the fact that in the latter ulceration is early, and the ulcer presents everted edges, and is covered with a thin bloody discharge. Epithelioma is, moreover, attended with more or less pain. Ulceration due to lupus may be mistaken for syphilitic disease, but differs therefrom in several important respects. In the early stage of lupus, small patches of papules or tubercles make their appearance, and after a time slowly break down and ulcerate. There is little discharge, but crusts and scales form, and some amount of cicatrisation takes place.

Treatment.—The treatment of primary syphilis of the auricle is the same as that of chancres elsewhere. Mercury must, of course, be given internally, and black wash or an ointment composed of vaseline and Unguent. Hydrargyri, equal parts, should be applied to the sore. Condylomata likewise require the internal use of mercury. The best local remedies are calomel and oxide of zinc, in equal parts, applied by means of a brush. Nitrate of silver may be employed to reduce the size of granulations; and when many condylomata exist, a plug of lint, smeared over with mercurial ointment, should be kept in the meatus. Gummatous ulceration will require iodide of potassium to be given internally and local treatment with antiseptic solutions or ointments.

---

* *The Ear: its Anatomy, Physiology, and Diseases*, p. 222.

† *Arch. f. Ohrenheilkunde*, vol. xx. p. 242.

Bony growths of the meatus, due to syphilis, will be considered in a subsequent chapter. The author is strongly of opinion that mercury should be administered in *all* cases of syphilis, irrespective of the stage, and that iodide of potassium should be given *in addition*, as long as the so-called secondary symptoms are present, and in the later stages of the disease. In order to prove efficacious, the internal exhibition of mercury should be continued from eighteen months to two years. The Pil. Hydrargyri and the Hydrarg. c. Cretâ are the best preparations, and the addition of iron is usually beneficial. The following is a good formula:—

Hydrarg. c. Cretâ, gr. i.
Ferri Redact., gr. i.
Glycerin. Tragacanth., q.s. to make pil. i.;

and two or three of these may be taken daily for many months without producing salivation or any undesirable result.

Unless there is serious inflammatory mischief present which renders it necessary to place the patient as quickly as possible under the full action of mercury, it is a mistake to give this drug in doses which produce salivation. The best results are obtained by giving small doses daily for a long period. The author usually prescribes two or three of the Hydrarg. c. Cretâ et Ferri Redact. pills daily for six or eight months; the patient should then discontinue them for a month, and subsequently take them for three months and suspend their use for one month alternately during another year or eighteen months.

CHAPTER XVIII.

W FORMATIONS OF THE AURICLE AND EXTERN
MEATUS.

a—Fibroma—Cysts—Sarcoma—Epithelioma—Lupus—Oste
-Exostoses—Symptoms and Treatment—Case of Exostos
noved by Drill and Screw.

ormations of various kinds, some being very rare, ar
n the external ear. They may be developed primar
rt, or may spread thither from adjacent structures.
of growths are connected with the auricle and others
atus, while in a third class both portions of the ext
the seat of disease.

THE AURICLE.—The principal new formations occurrin
rtion of the ear may be classified under the heading
na, Fibroma, Cysts, Sarcoma, and Epithelioma. Ulc
ue to lupus, will also require notice.

gioma.—Vascular formations of this class are not
n in the auricle. Of the two kinds, simple or plexif
vernous angiomata, the former can scarcely be regarded
s, as they do not project above the level of the skin. Th
as bright red or livid patches, of varying size, and n
off very sharply from the normal tissue. They ar
congenital, and may either remain stationary or increas
; their colour is due to enlarged blood-vessels, which ar
n the corium or subcutaneous fat. The cavernous angioma
bluish-red tumour, made up of a series of cavities of
shapes, and separated from each other by incomplete
partitions. These tumours are sometimes congenital, but
to be developed from simple angiomata by continued

[illegible] ...ing. If all other means fail, removal of the [illegible] less of the auricle, may become necessary.

Fibroma. [illegible] of this character most often occur in [illegible] result of the irritation caused by wearing ear- [illegible] the ear for their reception. Instances [illegible] common among negresses in various par[illegible] The tumours consist of spindle cells and connecti[illegible] be considered as resulting from hypertrophy [illegible] They are more or less rounded in form, and [illegible] each side of the lobule; the surface is e[illegible] [illegible]; they vary in size, some being as lar[illegible] Tumours of the same nature are occasionally [illegible] of the auricle. A case of fibroma [illegible] auditory canal has been described by Dr. S[illegible] The growth was as large as a small waln[illegible] covered by cutis and partially supp[illegible] and ulcerated over a small area.

[illegible] when they cause deformity that these [illegible] treatment. Small tumours may be re[illegible] [illegible] incision, the edges being afterwa[illegible] together by sutures. If the tumour be[illegible] be cut off with scissors, and when a[illegible] each side of the lobule it is well, after [illegible] the remains of the pedicle with the [illegible] with a large growth, careful disse[illegible] to retain as much of the integu[illegible]

[illegible] **Formations,** occurring in the auricle, are [illegible] of glandular dilatation and accumulat[illegible] They appear as roundish soft tum[illegible] one case recorded by Gruber, the tumo[illegible] in diameter, and was situated on the pos[illegible] It had existed for five years, and [illegible] increase for two years.

[illegible] occasionally become developed in the auricle, [illegible] resemble othæmatoma, for which they [illegible] They differ therefrom, however, in co[illegible] sero-mucous fluid, and in not produci[illegible] stage. It is also worthy of note that [illegible]

[illegible] *Archives of Otology*, 1895, p. 269.

CHAPTER XVIII.

NEW FORMATIONS OF THE AURICLE AND EXTERNAL MEATUS.

Angioma—Fibroma—Cysts—Sarcoma—Epithelioma—Lupus—Osteomata —Exostoses—Symptoms and Treatment—Case of Exostosis Removed by Drill and Screw.

New formations of various kinds, some being very rare, are met with in the external ear. They may be developed primarily in this part, or may spread thither from adjacent structures. Some kinds of growths are connected with the auricle and others with the meatus, while in a third class both portions of the external ear are the seat of disease.

I. The Auricle.—The principal new formations occurring in this portion of the ear may be classified under the headings of Angioma, Fibroma, Cysts, Sarcoma, and Epithelioma. Ulceration, due to lupus, will also require notice.

Angioma.—Vascular formations of this class are not uncommon in the auricle. Of the two kinds, simple or plexiform and cavernous angiomata, the former can scarcely be regarded as tumours, as they do not project above the level of the skin. They appear as bright red or livid patches, of varying size, and not marked off very sharply from the normal tissue. They are usually congenital, and may either remain stationary or increase in size; their colour is due to enlarged blood-vessels, which are seated in the corium or subcutaneous fat. The cavernous angioma forms a bluish-red tumour, made up of a series of cavities of various shapes, and separated from each other by incomplete fibrous partitions. These tumours are sometimes congenital, but they may be developed from simple angiomata by continued dilatation of the enlarged vessels. The helix and the anterior surface of the auricle are the parts most commonly affected; but when the meatus is the place of origin, the growth may extend to the posterior surface of the auricle. The tumours vary in size, the largest observed being perhaps equal to a walnut; the surface is more or less irregular, and pulsation is occasionally manifest. Several tumours of this kind may exist in the same patient. Nothing definite can be stated with regard to their cause; in one instance, the tumour appeared after the auricle had been frozen. The rapidity of their growth varies, and when they are slowly developed they cause little, if any, pain. When, however, they grow quickly, and attain a large size, the pulsations are apt to be very disagreeable to the patients. Reflex cough has been observed in a case in which the angioma occupied the meatus, and deafness will, of course, result if the canal be occluded. Tinnitus may also be very troublesome. Hæmorrhage is, however, the most important symptom connected with these growths; it may be so profuse as to require ligature of the carotid.

The **Diagnosis** of angioma of the auricle or meatus can never be difficult; othæmatoma is the only other tumour with which it is likely to be confounded. The history of the case, the rapid development of the growth, and the uniform smoothness of the surface will serve to distinguish tumours due to hæmorrhage.

Treatment.—This must depend upon the size and extent of the tumour. When small, vaccination of the surface and brushing it over with nitric acid are two measures that have been proposed; the resulting cicatrices cause more or less contraction. Politzer recommends that several aseptic silk threads, saturated with perchloride of iron, should be passed through the tumour, with the view of causing coagulation and atrophy. In larger growths the same results may be attained by means of the Paquelin or the galvano-cautery. Electrolysis may also be employed with advantage; the needle connected with the negative pole is passed into the tumour, and causes complete coagulation within a few minutes. Injections of carbolic acid (1 to 10 of glycerine and water) sometimes prove efficacious. Injections of the perchloride of iron are not to be recommended, inasmuch as there are several dangers connected with them. Suppuration may take place in the tumour, with pyæmia as a result; and if this danger be avoided, extensive sloughs may form, the separation of which may be followed by uncontrollable bleeding. If all other means fail, removal of the tumour, with more or less of the auricle, may become necessary.

Fibroma.—Growths of this character most often occur in the lobule, as a result of the irritation caused by wearing earrings, or by piercing the ear for their reception. Instances of this kind are somewhat common among negresses in various parts of the world. The tumours consist of spindle cells and connective tissue, and are to be considered as resulting from hypertrophy of the cicatrix. They are more or less rounded in form, and frequently project on each side of the lobule; the surface is either smooth or furrowed; they vary in size, some being as large as a hen's egg. Tumours of the same nature are occasionally seen on other portions of the auricle. A case of fibroma at the entrance of the auditory canal has been described by Dr. Scheibe,* of Munich. The growth was as large as a small walnut, club-shaped, rather hard, covered by cutis and partially supplied with hair and glands, and ulcerated over a small area.

It is only when they cause deformity that these growths require surgical treatment. Small tumours may be removed by means of a V-shaped incision, the edges being afterwards carefully brought together by sutures. If the tumour be pedunculated, it may be cut off with scissors, and when a growth projects from each side of the lobule it is well, after using the scissors, to destroy the remains of the pedicle with the galvano-cautery. In dealing with a large growth, careful dissection is necessary, in order to retain as much of the integument as possible.

Cystic Formations, occurring in the auricle, are in most cases the result of glandular dilatation and accumulation of sebaceous materials. They appear as roundish soft tumours of variable size. In one case recorded by Gruber, the tumour was more than an inch in diameter, and was situated on the posterior surface of the auricle. It had existed for five years, and had remained without increase for two years.

Serous cysts occasionally become developed in the auricle, and more or less closely resemble othæmatoma, for which they are liable to be mistaken. They differ therefrom, however, in containing a clear yellow sero-mucous fluid, and in not producing deformity at a later stage. It is also worthy of note that no masses of detritus and no shreds of fibrin are found in the fluid. They are situated between the perichondrium and the cartilage, and their formation is preceded by softening and fibrillary disintegration of the latter structure. It is probable that various transitional forms exist; some containing more or less blood; and others, only serum. The persons affected are for the most part robust and healthy; only one case occurring in a female has as yet been reported. With regard to their origin, they sometimes appear after slight injuries to the part; in such cases they are rapidly developed, but are not painful. In other cases they are developed spontaneously, and also increase somewhat rapidly.* These cysts sometimes become inflamed, with suppuration and spontaneous cure as results. Small cysts on the auricle may be removed by suitable incisions; when large, they are best treated by making a free incision into the tumour, and, after the escape of the fluid, filling the cavity with iodoform gauze.

---

* *Archives of Otology*, 1895, p. 269.

Sarcoma.—Tumours of this character are rarely seen in the external ear, and only a few cases have been placed on record. In one described by Hartmann,† the patient was a boy, aged three and a half years, who had suffered for some time from acute purulent inflammation of the tympanum. The tumour, a round-celled sarcoma, was as large as a goose's egg, and projected from the side of the head. Death ensued in seven months with cerebral symptoms.

Fibro-sarcomata and spindle-celled growths have also been noticed; these grow slowly, and may exist for years without giving rise to any marked symptoms; but the small-celled sarcomata rapidly increase in size, and are very painful, as they are apt to involve many sensory nerves, and to set up inflammation in neighbouring tissues. The parotid and mastoid regions are especially liable to be thus implicated.

The symptoms vary according to the variety of the growth; the sarcoma may appear as a circumscribed, reddish, more or less firm tumour, covered by normal cutis; in other cases the surface is eroded, or ulcerated and irregular, and covered with offensive muco-purulent matter. When the growth is of the round-celled variety, its increase is very rapid; masses of fungous granulations sprout from its surface. In a case recorded by Dr. Orne Green,* a spongy, highly vascular, fleshy mass occupied the left meatus, to the walls of which it seemed to be adherent. The tumour eventually measured eight inches in length, and six in breadth. Evidences of glandular irritation and of inflammation in adjacent parts may be present or absent; in the stage of ulceration there is copious fœtid discharge, and hæmorrhage is liable to be profuse; metastatic growths are sometimes seen in other organs. Paralysis of the facial nerve is likely to occur as a result of the extension of the growth.

---

* See an article on "Cyst Formations in the Auricle," by Dr. Arthur Hartmann, *Archives of Otology*, vol. xv. p. 133; and another paper by the same author, vol. xvii. p. 233. A case is also recorded by Dr. Seligmann, *Archives of Otology*, vol. xvi p. 41.

† *Zeitschrift f. Ohrenheilkunde*, Bd. viii. S. 213.

Bezold† has recorded a case of pedunculated osteo-sarcoma of the external meatus. It appeared, in the osseous portion, as a hardish tumour, irregular in shape, with a red and white excoriated surface, over the superior and posterior parts of which a probe could be passed. At the anterior wall the tumour appeared to be connected with the bone. When removed with the snare it was found to be oval, as large as a bean, and attached to the anterior superior wall. Microscopical examination proved it to be pervaded by osseous strands, extending from the pedicle. Such a growth is of very rare occurrence.

The **Diagnosis** can be positively determined only with the aid of the microscope, a fragment of the tumour having been removed for examination. A round-celled sarcoma is usually white on section, and a milky juice exudes from the cut surface. The structure consists almost entirely of round cells and vessels, the former being small and fragile, and inclosing a rounded vesicular nucleus. Fibro-sarcomata contain much intercellular substance, and the tumours are firm and coarse-grained.

The **Prognosis** depends upon the nature of the growth and the rapidity of its development. The small-celled sarcomata increase rapidly, and death may soon result from extension to the brain, or from hæmorrhage and exhaustion. In osteo-sarcoma the prognosis is better than in pure sarcoma.

Treatment.—The tumour should be removed as soon as possible. Fibro-sarcomata may be dealt with by the knife or the galvano-cautery loop; and round-celled tumours with the wire loop. After removal, the galvano-cautery should be applied to the surface, in order to destroy, as far as possible, all remains of the growth. Sometimes partial removal is all that can be achieved, and such an operation may be necessary to provide for the escape of purulent matter from the meatus.

---

* *Archives of Otology*, vol. xiii. p. 153.

† *Ibid.*, 1895, p. 270.

Epithelioma.—This form of growth may have its starting-point in the auricle (usually in the upper half), or in the external meatus, or it may spread to these parts from adjacent structures. Nearly fifty cases have been placed on record, very few of the patients being under forty years of age.[*] In the auricle the disease commences in the form of one or more hard nodules situated in the skin or subcutaneous connective tissue. At first, and for some time, their growth is a slow process, but afterwards it becomes more rapid; the surface sooner or later breaks down, and an ulcer results. Both surfaces of the auricle would appear to be equally liable to cancerous growth. Sometimes warty growths are the starting-point of epithelioma. The surface becomes fissured and the cracks form ulcers with indurated edges and roughened surfaces. As the growth enlarges, epithelial nests, made up of large multiform squamous cells, may sometimes be pressed out of it. Fresh formation of new tissue, to be followed by disintegration, goes on at the margin of the ulcer, and thus the process of destruction spreads, until not only the entire auricle and meatus may be involved, but the mischief may extend to neighbouring parts and to the bones of the skull. In some cases the appearance of epithelioma in the meatus is preceded by some other affection of the ear, such as purulent inflammation; but in others the disease attacks a perfectly healthy canal. Epithelioma of the meatus may also begin with symptoms of eczema, or as a small crust beneath which an ulcer is developed. The process extends and involves the tympanum and bones of the head.

The development of the nodules on the auricle is unattended with pain, and some months may elapse before any glandular enlargement appears. When disintegration commences the pain becomes a prominent symptom, and it increases with the progress of the disease. As the deeper parts of the ear are gradually involved, the pain becomes excruciating. In addition to symptoms of irritation of the auditory nerve, the course of the disease will be further marked by profuse hæmorrhage, great swelling and induration of the glands of the neck, and facial paralysis; the fatal issue may be due to meningitis, thrombosis of the lateral sinus, or to cerebral abscess. Septicæmia is another cause of death in these cases.

---

[*] See Moos, *Archives of Otology*, vol. xiii. p. 239; Fougeray, *Annal. des Mal. de l'Oreille*, April, 1890; Spalding, *Archives of Otology*, vol. xxi. p. 299; Crawford. *Brit. Med. Journ.*, March 18, 1893; Sumpter, *Lancet*, April 15, 1893, and May 5, 1894 (case of epithelioma of the external ear on both sides).

Treatment.—As soon as the malignancy of a growth confined to the auricle has been determined, removal of the portion should be at once effected. The application of caustics is not advisable; extension of the growth is the ordinary result of the irritation. Removal of the entire auricle may be necessary, and in such a case the meatus must be carefully kept open during cicatrisation. An artificial ear can afterwards be adapted. In circumscribed epithelioma of the meatus, an attempt may be made to excise the growth and to destroy with a cautery any tissue which is possibly involved, but which cannot be removed on account of its position. When operative interference is undesirable, the case must be treated in the ordinary manner. Remedies to relieve the pain, and local deodorant or antiseptic applications are always required.

Lupus.—Lupous ulceration confined to the auricle and meatus is extremely rare; but extension of the process from adjacent parts of the face is not uncommon. The ulceration of the auricle presents the usual appearance; the surface of the sore is covered at intervals with thick crusts of pus and blood; the margin is livid and swollen, and contains small nodules of granulation-tissue. The entire auricle may be destroyed, and the ulceration may extend along the meatus to the membrana tympani. The pain varies in degree in different cases; it is apt to be very severe when the deeper portion of the canal is involved.

When lupus begins in the auricle, small nodules are formed in the deeper layer of the cutis. These unite and become confluent, and while some shrink and almost disappear, others soften and are converted into ulcers, along the edges of which the process is repeated. Some efforts at repair likewise occur, as in other parts. Brieger* reports a case in which a nodule of lupus was developed in the lobule at the spot where the ear had been pierced for a ring. The patient was a woman aged twenty-five, the subject of pulmonary phthisis.

There is a variety of the disease termed *maculosus*, and characterised by the formation of brown tubercles, as large as a pin's head or a lentil. These have been observed on the lobule, in the hollow of the concha, and on the posterior surface of the auricle. They seldom ulcerate, but shrivel up, and cause atrophy and puckering of the integument. The spots are covered with minute scales, resembling those of psoriasis, but less abundant than in that complaint. There is yet another form, termed *lupus hypertrophicus*, which is sometimes observed as a consequence of lupous ulceration (Politzer). It is characterised by the formation of glandular and papillary outgrowths from the tissue of the granulations in the floor of the ulcer. These outgrowths are spongy in texture and readily bleed; in some instances they are said to have become hard on the surface, suppuration continuing at the base. The destruction of the integument goes on in the usual way; the development of lupous nodules in the corium is followed by their disintegration, and large portions of the auricle, or even the whole of the organ, may be thus destroyed.

---

* *Klin. Beiträge z. Ohrenheilkunde.* 1896, S. 20.

The **Treatment** of lupus of the auricle is the same as when the disease occurs in other parts. The affected portions should be freely curetted, and afterwards touched with a galvano- or Paquelin's cautery. In some cases it is best to excise the diseased area, and, if necessary, graft any surface which may be left exposed.

II. THE EXTERNAL AUDITORY MEATUS.—Most of the new formations just described as affecting the auricle likewise occur in the meatus, and generally as the result of extension; but there is one form of growth which necessarily implicates only the meatus, and requires to be described at some length.

Osteomata.—Osseous growths occur in several forms in the external meatus (1) as a diffused thickening of the normal osseous tissue, or *hyperostosis*; (2) as small pointed or rounded projections, which are due to inflammatory processes, and may be termed *osteophytes*; and (3) as circumscribed rounded tumours, or *exostoses*.

(1) **Hyperostosis** of the external meatus is due to chronic periostitis, and consequent increased formation of osseous tissue, and is generally connected with chronic purulent or other disease of the middle ear. The deposit of bone is of uniform thickness, and involves more or less of the osseous part of the canal; it

may be confined to one side. The surface is slightly rough, and the integument is redder than natural and swollen. As a result of the deposit, the meatus is more or less contracted, and hearing may be impaired. The deafness, however, is more often due to the morbid changes in the middle ear, or to accumulation of secretion behind the narrowed portion. Examination with the probe will detect the nature and length of the stricture.

There is another form of hyperostosis, in which the enlargement is limited to the tympanic portion, and occurs in the absence of any changes which could possibly be referred to previous inflammation. According to Dr. Hartmann,* of Berlin, this condition is uniformly bilateral, and hereditary influence is often traceable. The anomalous formation begins with the development of the external meatus, and becomes evident as the growth of the tympanic portion progresses. The hyperostosis advances at the anterior and posterior walls of the meatus, chiefly towards the middle line, and remains stationary when adult life is reached.

(2) **Osteophytes** are likewise the results of chronic inflammation, but the enlargement, instead of being diffused, takes the form of small elevations, extending for some distance over the surface. The *treatment* consists in cleansing the meatus by syringing, and in applying proper remedies to the swollen integument (*see* Treatment of External Otitis, page 207). Soothing ointments (*e.g.*, Unguent. Acid. Boric.) may be applied to the meatus, while tincture of iodine is painted over the mastoid process. When success has been attained, any disorder of the middle ear should be carefully treated. As the contraction is apt to return, it may be necessary to repeat the local treatment from time to time.

(3) **Exostoses** are somewhat common in the external meatus. These are little masses of either compact or spongy osseous tissue, and more or less globular in form; they are most prone to affect the posterior wall and the outer third of the canal, but they are sometimes found near the tympanic membrane. With regard to their etiology, some authorities believe that local sources of irritation, and especially sea-bathing, are the most important factors. They are sometimes of syphilitic origin, and are associated with similar growths from other bones. They also occur in cases in which there is no venereal taint; sometimes they are asso-

---

* *Archives of Otology*, vol. xxvi. p. 43.

ciated with gout and rheumatism, but more often with inflammatory processes in the meatus or tympanum.* Flat and mammillary exostoses, of moderate size, are not uncommon in chronic catarrhal and purulent otitis. Another mode of origin is from cartilaginous and connective tissue growths, such as chondromata and polypi, which become partially ossified. Growths thus caused are for the most part single, and consist of a very hard nucleus, from the surface of which trabeculæ of bone project into a layer of fibrous tissue, the whole being attached to the outer edge of the osseous meatus by a bony pedicle (Pritchard). The association of exostoses with obliteration of the Eustachian tube has been noticed in some cases, the obstruction in the latter part being probably due to osseous growths. Toynbee states that exostoses in the meatus are sometimes connected with similar formations in the deeper structures of the ear. Aural growths are much more common in males than in females. It is interesting to notice that they are somewhat frequently found in the skulls of certain aboriginal tribes (mound-builders) of North America.†

Two bony prominences are sometimes seen in the upper wall of the meatus, close to the membrana tympani, one being in front of the other, and both ears being affected. These correspond with the line of union between the annulus tympanicus and the temporal bone, and probably depend upon the occurrence of irritative processes in early life.

Symptoms.—The development of exostoses is not attended with pain; only after some time, when the growth impinges against the opposite wall of the meatus, is any inconvenience experienced. In the not uncommon case of multiple growths, their surfaces may soon come into contact, when much pain will be felt. Impairment of hearing will also depend upon the size of the growth and the extent to which the meatus is obstructed. When examined with a probe, the growths are sometimes found to be very tender. In a case recorded by Dr. H. Knapp,‡ fits of coughing were induced by touching the growth with a probe. Complete obstruction of the meatus may be due to accumulation of cerumen and epidermic scales between the growth and the wall of the canal, and under such circumstances the deafness will vary in degree from time to time.

---

* See notes of a case of pedunculated bony growth in external meatus, the result of prolonged suppuration, *Archives of Otology*, vol. xii. p. 59.

† Dr. C. J. Blake, *American Journ. of Otology*, vol. ii. No. 2.

‡ *Archives of Otology*, vol. xi. p. 203.

On examining the ear, an exostosis appears as a globular or elliptical swelling connected with the wall of the meatus, and either sessile or somewhat constricted at its point of attachment. Unless it be covered with granulations, the tumour is hard and firm, and its size varies from that of a hemp-seed to that of a small nut. It may extend to the opposite wall, and when two or more exostoses are present, their convex surfaces may so approximate as to leave only a small chink. Polypoid excrescences not infrequently appear on the surface. The growths are sometimes found in both ears, exhibiting a remarkable degree of symmetry in their form and position. Their structure is that of perfectly formed bone-tissue. They increase very slowly in size, and may remain for years without undergoing any further change in dimensions. In a few cases, the growths have been noticed to decrease in size and finally to disappear.

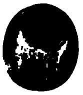


FIG. 68.

EXOSTOSES IN RIGHT MEATUS occurring in a lady now forty-four years of age. When the patient was first seen, fourteen years ago, the four growths were the same size as they are at the present time. The hearing of the right ear was then normal, and it still remains so.

Exostoses of the auditory canal, when associated with chronic suppuration of the middle ear, may cause retention of the discharges and grave consequences within the cranium. Their presence is always a serious complication of chronic suppurative otitis. In a case recorded by Dr. Munson,* of Albany, N.Y., chronic otorrhœa had led to the formation of an exostosis, which, with polypoid tissue, almost completely occluded the canal. The patient refused to submit to any operation, although there were symptoms indicative of cerebral mischief; delirium supervened, followed by coma, and death ensued in less than twenty-four hours. Post-mortem examination revealed an abscess as large as a hen's egg in the middle lobe of the brain, caries of the superior wall of the petrous bone immediately above the semicircular canals, and a corresponding perforation in the meninges.

---

* *Archives of Otology*, vol. xi. p. 29. See also the records of another case in which the cerebral symptoms were completely relieved by removal of the exostosis, *Ibid.*, vol. xix. p. 144.

Diagnosis.—The history of the case, the appearance of the growth, and an examination with a probe, will serve to distinguish an exostosis from other tumours of the meatus. Its hardness, slight tenderness, and the absence of redness, contrast with the symptoms of an abscess; moreover, the latter is further distinguished by the changes it undergoes. When the meatus is inflamed and swollen, and the projecting growth is covered with secretions, or presents granulations, it might be mistaken for a polypus, but an examination with the probe will detect the hardness of an exostosis.

Treatment.—Unless the meatus be considerably obstructed, an exostosis need not be interfered with; but care should be taken to prevent accumulation of cerumen and epithelium in the deeper portion of the canal. If the meatus be much diminished in calibre, or completely obstructed, and especially if there be an accumulation of pus behind the growth, as would occur in suppurative otitis media, measures must be adopted for the removal of the latter. The local application of remedies to produce absorption, and the introduction of tents with the same view, are very rarely successful, their effects, if any, being mostly confined to the soft parts.

In many cases it is best to expose the osseous meatus by making an incision about an eighth of an inch behind the attachment of the pinna, extending from near the tip of the mastoid process to a point above the meatus; then turning the ear forward and dividing the posterior, superior, and inferior walls of the cartilaginous meatus at its attachment to the bone. This having been done, the exostosis can be removed by a mallet and chisel, or a burr driven by an electric motor or a dental engine, and being close to the surface can be much more easily dealt with than through the meatus. As an exostosis is often smooth and very hard, great care must be taken to prevent the chisel or burr slipping and injuring deeper parts.

All operative measures for the removal of exostoses through the meatus require the greatest care, and should be undertaken only by those who are accustomed to deal with diseases of the ear. For sessile exostoses, Dr. Mathewson, of New York, was the first to suggest the use of the American dental drill, and the plan has been since generally adopted. The operation should be performed as follows:—The patient is placed on a high couch (about forty-two inches from the ground), with pillows under his head, so arranged that a strong light may be reflected into, or fall upon, the affected ear. An anæsthetic having been administered, an assistant holds round the exostosis or against the walls of the meatus, according to the position of the outgrowth, a copper or steel guard, to prevent injury from the drill slipping whilst in action. Although a steel guard is the better of the two, on account of its greater hardness, a copper one is often the more serviceable, as its curve can be readily altered to enable it to be placed in different positions. In all cases the guards should be previously tried, in order to ensure that they fit well against the parts which they are intended to protect. Three or four assistants are necessary, one to give the anæsthetic, a second to work the treadle of the drill, while a third holds the guards in the ear. It is necessary also to sponge or syringe away the blood which flows into the meatus. When dealing with **sessile exostoses,** it is well to begin with a small drill, and to widen the opening with a larger instrument. The hole should be commenced midway between the base and summit of the growth, and in the early stages of the operation too great care cannot be taken to prevent the drill slipping. Firm pressure should never be made with the drill, for if it slips whilst this is being done, serious injury may be caused to the middle and internal ear. It is necessary frequently to take out the instrument in order to remove the blood so that a view can be obtained of the tumour. As the operation should not be hurried, from one to two hours may be required to drill through the growth; and if, after this has been done, it is considered undesirable to prolong the operation, the remainder of the exostosis may be removed on another occasion. After a few days the opening may be enlarged with other drills until the growth has been removed. This treatment is applicable to very hard exostoses, and for cases in which the tumour is composed of soft bone; but when dealing with the latter, an attempt may be made to break away the growth with a pair of suitable forceps, after a hole has been drilled into it.

For the removal of aural exostoses, Dr. Urban Pritchard* suggests the use of a minute trephine, instead of a solid burr.

---

* *Archives of Otology*, vol. xx. p. 45.

The instrument is applied as near the base of the growth as will permit its circumference to rotate freely above the apex, the object being to cut off a portion, rather than to make a hole in the swelling. Dr. Pritchard claims that the trephine causes less débris and hæmorrhage, and removes a far larger portion of bone than when a hole is drilled.

For the removal of a **pedunculated exostosis** through the meatus the author considers that the safest method is to drill a hole into it, by means of an electric motor or a dental engine, and then insert the tapering screw (Fig. 73) until a firm hold has been obtained. Gentle traction should then be made, and the growth broken off at its pedicle and removed from the meatus, attached to the screw. If traction alone fails to break the pedicle, the direction of the force should be varied. Before beginning the operation several drills of different sizes should be provided, and a tapering screw made for each, with its end slightly smaller, and its broadest part larger, than the hole made by the drill. Care should be taken not to insert the screw too far into the growth, in case it should split it, and thus prevent a firm hold being obtained.

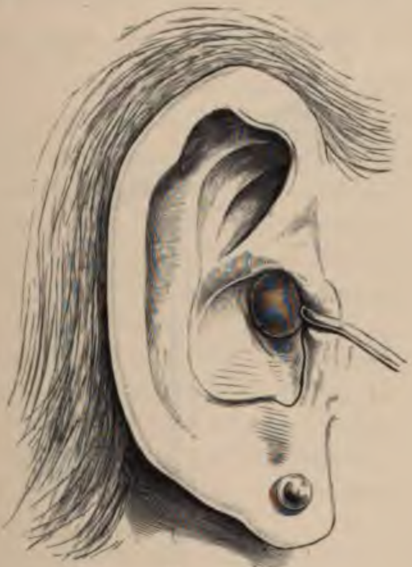


FIG. 69.

THE EXOSTOSIS BEFORE REMOVAL.

As it would appear that this method of removing a pedunculated exostosis had not previously been devised, the author mentions the following case, illustrated by woodcuts of the instruments employed.

M. C., a Dutch Jewess, aged twenty-two, was admitted into the London Hospital in November, 1892. There was a purulent discharge from her left ear, which had been present for some time, but she came on account of a pain in the right ear, which had existed for about six months, and was of daily and frequent occurrence.

There was no discharge from the right meatus, but the hearing on this side was considerably impaired, and had been defective since the commencement of the pain. On making an examination, a hard, smooth, whitish mass, with a rounded outline and tender to the touch, was seen filling the meatus, its outermost part being about an eighth of an inch from the entrance.

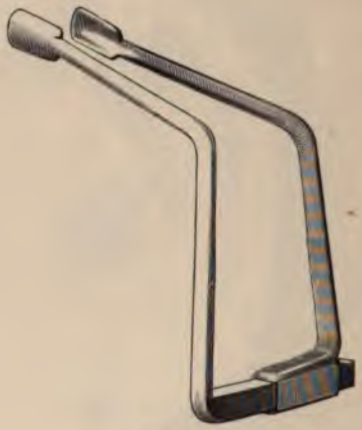


FIG. 70.

SELF-RETAINING GUARD.

A very fine probe could with difficulty be passed between the exostosis and the walls of the canal for about a quarter of an inch, but no attachment could be felt.

The patient having been anæsthetised, the meatus was well illuminated by a strong light reflected from a frontal mirror, the lateral walls protected by the self-retaining guard (Fig. 70), and

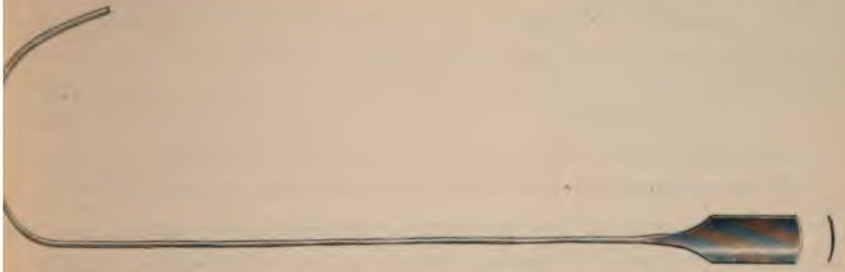


Fig. 71.

Copper Guard, its Curve shown by the Line on the Right.

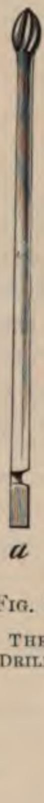


Fig. 72.

The Drill.

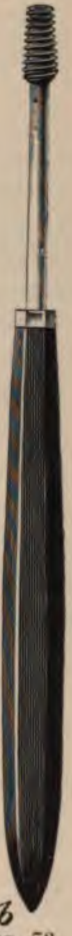


Fig. 73.

The Screw Extractor.

its roof and floor by two copper guards (Fig. 71), held by an assistant. A hole was then carefully bored into the exostosis with the drill (*a*, Fig. 72) attached to a dental engine, and when this had been made of a sufficient depth to enable a firm hold to be obtained, the screw (*b*, Fig. 73) was inserted. On traction being made, the pedicle was felt to break, and the exostosis firmly fixed to the screw was withdrawn from the meatus.

Examination of the growth (Fig. 74, natural size) showed that it had been attached (at *a*) to the junction of the upper and anterior walls. Hearing was restored on removal of the growth, and stated to be as good as it was before the onset of the pain.

The use of a small mallet and chisel has been recommended for detaching a pedunculated exostosis; but this method of treatment is not suitable for all cases. When the tumour is large, on account of its close proximity to the walls of the meatus, it is often extremely difficult, and sometimes impossible, to discover the position of the pedicle; and in the latter case, if it is to be broken, the whole growth must be forced inwards, a procedure which is undesirable, as the size of the growth and consequently its position as regards the tympanum, are unknown. If the exostosis is large, and situated deep in the meatus, there may be considerable difficulty in removing it after it has been detached. When the chisel can be directly applied to the pedicle, great care must be taken to prevent its being driven against deeper structures immediately the resistance ceases which has been offered by the growth. In most cases where the mallet and chisel have been used, the auricle and cartilaginous portion of the meatus have previously been dissected off and held aside.

The removal of a pedunculated exostosis by an electric snare is another method of treatment which has been employed. In many of the cases it seems probable that traction did more to sever the pedicle than the heat of the wire, the latter serving principally to destroy the tissues in contact with the growth, so that the loop could be passed over it. In the case of a small pedunculated exostosis, the electric snare is not required, and when dealing with a large one there is risk of injury to other parts by employing a cautery in a position which cannot be clearly seen.

FIG. 74.

THE EXOSTOSIS AFTER REMOVAL.

CHAPTER XIX.

FOREIGN BODIES IN THE EAR.

Classification of Foreign Bodies: Vegetable, Animal, Mineral—Symptoms caused by Insects in Meatus—Treatment—Symptoms caused by Non-living Bodies—Reflex Symptoms—Symptoms often Aggravated by Attempts at Removal — Diagnosis — Prognosis — Treatment, Various Methods and Precautions—Substances Liable to be Swollen by Moisture—Various Instruments for Extracting Foreign Bodies from Meatus—Course to be Pursued when Extraction by Ordinary Methods Impossible—Partial Separation of Auricle.

A CONSIDERABLE number of substances, of very different kinds, find their way into the external auditory meatus, where they are apt to give rise to symptoms and disturbances varying both in kind and degree. On the other hand, they sometimes remain, even for years, without causing obvious inconvenience. To enumerate the articles that have been found in the external meatus would be a work of some length ; they may be conveniently divided into several categories according to their nature.

(1) **Vegetable Substances.**—A large number (about 75 per cent. of all cases) are derived from the *vegetable* kingdom. It is sufficient to mention seeds of various kinds—peas, beans, cherry-stones, grains of wheat and barley—fragments of straw, pieces of wood, pencils, cork, plugs of cotton, pieces of india-rubber, etc. These, again, may be divided into two classes, according to their liability to swell, or the contrary. It is obvious that this distinction is a very important one, especially as regards treatment.

(2) **Animal Substances.**—Articles of *animal* origin are found in about 15 per cent. of all cases ; the list includes various

insects, as flies, cockroaches, fleas, bugs, caterpillars, etc.; bacon-rind, ivory, bone, teeth, and wax.

(3) **Mineral Substances.**—Among articles of *mineral* origin (10 per cent. of all cases) come buttons, shot, beads, pebbles, rings, pieces of chalk, slate-pencil, glass, pin-heads, etc. A case in which a mass of molten lead (or solder) fell into the ear of an old man has been recorded by Mr. M. Sheild.*

Children constitute the majority of patients, and in most cases the articles are introduced intentionally, either by the child itself or by a companion. An upper incisor tooth has been found in the meatus, where it had remained for about three weeks.† Insects occasionally wander into the ears both of children and adults; but other foreign bodies are much more frequently met with. In the case of persons suffering from discharges from the meatus, flies are apt to be attracted to the part and to deposit their eggs. In the absence of any local disease, however, a fly has been known to crawl into the meatus and deposit its eggs. In one case,‡ fifteen larvæ had been present, of a yellowish-white colour and filled with blood, which showed through their bodies. The larvæ of the muscida sarcophaga soon become vigorous, and as their mandibles are furnished with strong hooks, they attach themselves very closely to the walls of the meatus, and are dislodged with difficulty. As many as 200 larvæ have been counted in one ear.

The **Symptoms** caused by insects in the meatus vary according to the amount of irritation which they set up in the canal and membrane. There may be only the sensation of something moving in the ear. Fleas, by jumping against the membrane, will cause loud and strange noises to be heard. Considerable irritation is caused by bugs, which are apt to attach themselves to the walls of the canal. Such insects as are provided with hooks will produce much irritation and severe pain. The earwig has been so named on account of its supposed propensity to crawl into the ears, but its reputation in this respect is undeserved. Though common in many parts of the country, and its numbers sometimes constituting a serious nuisance, it is not prone to crawl over the person, though it has a habit of creeping into tubes.

---

* *Lancet*, 1892, April 20, and *Diseases of the Ear*, p. 86.

† *Brit. Med. Journ.*, 1897, vol. ii. p. 810.

‡ *Archives of Otology*, vol. xx. p. 11.

Professor Hedinger,* of Stuttgart, reports one case in which an earwig was found in the ear, its head embedded in cerumen, and states that, so far as he knew, only one other case is mentioned in literature.

Other symptoms, besides pain and noises in the ears, are sometimes caused by the presence of insects in the meatus. In rare cases headache, giddiness, vomiting, epileptiform attacks and partial paralysis have been witnessed, their origin being demonstrated by the fact that they ceased after the insects were removed. On the other hand, the irritation may be so slight as to cause little, if any, annoyance. When pain is complained of in such cases, the cause is generally discoverable without much difficulty. Sometimes, as in the case of fleas, the movements of the insect may be detected. Small bugs are apt to adhere closely to the walls of the meatus, or to the membrana tympani, and may be difficult of discovery when partially covered up with secretion and epithelium. The larvæ of flies sometimes crawl out of the meatus, and are seen in the secretion in cases of otorrhœa. When the membrane is perforated or destroyed, these creatures readily gain access to the tympanum. They may be detected by their movements, and the dark colour of the posterior extremity.

The **Prognosis** in all these cases is for the most part favourable, inasmuch as insects can readily be removed from the ear. If there be already suppurative inflammation of the tympanum, the prognosis must depend upon its severity and previous course.

The **Treatment** consists in destroying or removing the insect by means of the syringe or forceps. Most insects are speedily killed by pouring water into the ear and allowing it to remain for a few minutes; they can then be easily removed by syringing. Larvæ, however, are rendered more lively by water, and cling firmly to the wall of the meatus. A little alcohol is still more efficacious, and oil of turpentine is also recommended for the same purpose. When the creatures are closely adherent to the walls or to the tympanum, their removal is less easy. A little tobacco-smoke or vapour of chloroform will suffice to stupefy or kill them, and they will then fall off; but if these means are not at hand, they can always be detached with the aid of fine forceps.

---

* *Archives of Otology*, vol. xv. p. 242.

The other foreign bodies already mentioned are far more frequently met with in the ear. The symptoms they cause depend upon the amount of force with which they have been introduced; and, secondly, upon the physical and chemical peculiarities of the substances themselves. It is not uncommon to meet with cases in which foreign bodies have remained for long periods in the ear without causing any appreciable symptoms.* Some degree of deafness and feelings of pressure or tension are, however, generally produced, and if the substance be pressed against the membrane, there will be noises in the ears of various kinds. When the foreign body is hard and rough, and especially if violent but fruitless efforts be made to remove it, more or less severe pain will be almost certainly present. In the majority of cases, the foreign bodies are found in the osseous portion of the meatus. Occasionally they are so far down as to injure the tympanic membrane. and in rare cases pass through it into the tympanum.

Various reflex symptoms are often caused by the presence of foreign bodies in the ears; some of them take an acute and others a chronic form, and those belonging to the first of these categories are sometimes intermittent and sometimes continuous. Among the acute reflex symptoms may be mentioned laryngeal irritation and violent cough, nausea and vomiting; and in one recorded case,† rigors, followed by febrile attacks, were due to the presence of a foreign body in the ear. Reflex symptoms,‡ chronic in their duration, have been noticed in the form of contractions of the limbs, paralysis, dizziness, disordered equilibrium, epileptiform attacks, convulsions, and spasmodic dysphagia. Hyperæsthesia and anæsthesia are of less common occurrence. Salivation has been known to occur as a result of retention of a plug of cotton-wool for several years; it ceased after removal of the plug. Disorder of the cerebral functions has been found to depend upon the presence of a foreign body in the ear. Thus, in the case of a schoolmaster, both of whose ears were plugged up with ceruminous secretion, there were such severe attacks of mental confusion, that he was often compelled to cut short the lessons he was giving. The symptom disappeared after removal of the plugs. The absence of giddiness and of noises in the ears was a notable feature in this case. Whatever form the symptoms may take, they are wont to subside after the foreign body has been removed.

---

* In one case, two apple-seeds had remained in the ear for forty years—*Archives of Otology*, vol. xviii. p. 194; see also vol. xx. pp. 218, 338. In another case, a pea was said to have been retained in the meatus for twenty-one years (*Lancet*, 1894, June 10).

† *Berlin. Klin. Woch.*, April 10, 1876.

‡ *Archives of Otology*, vol. xiii. p. 208.

In the majority of patients brought to the surgeon with foreign bodies in the ear, the symptoms have been aggravated by the attempts made to remove the offending substances. The latter are apt to be pushed inwards against, and even through, the membrana tympani; while the walls of the meatus are often lacerated by the instruments employed. Hence swelling, bleeding, and inflammation of the meatus are not uncommon. If several hours have elapsed, the parts may be so swollen as to conceal the foreign body from view. If the substance has been introduced into an ear already diseased, as in a case of purulent otitis, the symptoms of the latter will likewise exist.

The **Diagnosis** of a foreign body in the ear is sometimes quite easily made, and at other times it is very difficult. In young children especially, inflammatory swelling is soon set up, and the meatus becomes occluded. If the foreign body has been pushed through the membrane into the tympanum, it may elude discovery for a considerable time, during which serious mischief may be done. In some cases the shape of the canal makes detection difficult. The anterior wall sometimes bulges out considerably, so as to hide from view any substance lying against the tympanum. After foreign bodies have remained for some time in the meatus, they generally become coated with a layer of cerumen.

Prognosis.—In cases of foreign bodies in the ear, the *prognosis* is generally favourable, except when there are complications, or when the body is situated deeply in the tympanum, and has set up profuse suppuration, or when the pus is prevented from escaping, and head-symptoms have appeared. Under such circumstances, the prognosis must be very guarded. The seriousness of the case may be due to the rough and violent attempts at removal of the substance, quite irrespective of its nature, and cases of this kind, in which fatal meningitis or cerebritis has been set up, are by no means infrequent.

In not a few cases, foreign bodies, especially smooth ones, introduced into the ear, fall out without causing pain or other trouble; and in a somewhat numerous class, the substances remain for years without interfering with the patient's comfort.* In 1879 a child was brought to the author on account of earache of one or two days' duration. On examination, a small piece of white substance was seen lying against the membrana tympani, and on removing it by syringing it was found to be a portion of a shell. More than a month previously the child had been at the sea-side, and played at being partially buried in the sand. The pain did not return after the piece of shell was removed. Rough-pointed bodies are most likely to cause irritation and inflammation. In a few instances needles have been known to pass through the tympanum and Eustachian tube into the throat, whence they were discharged in the act of vomiting. In still rarer cases, the foreign body (*e.g.*, an oat-husk) has entered the pharynx from the mouth, and passed through the Eustachian tube and tympanum into the external auditory canal.†

Treatment.—The first step is to ascertain whether a foreign body is present, for it is not uncommon for patients to assert that such is the case when subsequent examination proves that they are mistaken. Serious injury has been inflicted in attempting to remove foreign bodies stated by patients to be in the meatus, but not visible on inspection. In one such instance,‡ fracture of the tympanic plate of the temporal bone was the result of attempting to remove a pin supposed to have passed into the meatus. In many cases, simple examination with the naked eye is sufficient; but for the detection of small bodies a speculum will generally be required. Care must be taken not to push the object deeper into the ear. Substances which have passed into the osseous part of the meatus are much more difficult to extract than those which are situated in the cartilaginous portion. Too much gentleness cannot be exercised in carrying out any operative measure that may be required, and in all cases it is essential that the meatus should be thoroughly illuminated. The instrumental extraction of a foreign body should never be attempted by an unpractised hand.

---

* See Hedinger's table in *Archives of Otology*, vol. xv. p. 228. and the papers already referred to on p. 242.

† *Berlin. Klin. Woch.*, 1878, S. 728.

‡ *Archives of Otology*, vol. xiv. p. 239.

When a foreign body is detected, injections of warm water should be employed to remove it. As a strong current is generally desirable, a powerful syringe (holding three to four ounces) should be used, with a fine nozzle, so that the stream can be watched and accurately directed between the substance and the wall of the meatus. Whilst this is being done the auricle should be drawn upwards and backwards (in children downwards and backwards). For heavy articles—*e.g.*, shot—it is recommended that, whilst the ear is being syringed, the patient's head should be placed in a position to facilitate the foreign body falling out. Injections are contra-indicated when the foreign body is cup-shaped and the concavity presents itself; and when there is a perforation in the membrana tympani, they may have to be discontinued on account of the coughing produced, or the loss of power resulting from the escape of the fluid into the throat through the Eustachian tube, or its presence in the tympanum causing giddiness.

When the foreign body is visible, but firmly resists all efforts at extraction by means of injections, it has been recommended to adopt the following method:—The point of a camel-hair brush is dipped in a strong solution of glue and carefully applied to the surface of the object, previously dried. A solution of mastic in spirit, or some one of the cements used for mending glass, would probably be more tenacious than glue. The brush is to be kept in position until the glue or cement is dry, when the foreign body can sometimes be drawn out with it.

In cases in which, owing to previous attempts at extraction, the meatus is swollen and inflamed, it will be best to adopt measures to relieve this condition before attempting to remove the foreign body; and except in the case of a substance which will absorb moisture there is a decided advantage in adopting this course. An ice-bag should be applied to the ear, and a little morphine may be injected hypodermically. A warm ten to twenty per cent. solution of cocaine dropped into the ear is at times desirable. When the swelling subsides, the foreign body is sometimes found to be comparatively loose. More active measures are requisite when there are symptoms of irritation of the brain, violent pain in the head, rigors, and vomiting, but even these, as well as the local symptoms, may often be relieved by the application of cold. In Mr. Sheild's case, in which some molten lead fell into the ear and became closely impacted, the meatus was filled with mercury, which, in the course of sixteen hours, so corroded the lead and reduced its size that the mass was easily removed with the syringe.

Substances liable to swell under the influence of moisture are apt to prove very troublesome when attempts are made to remove them, and those which possess this property are, unfortunately, often introduced into the meatus. Peas and beans are the foreign bodies most commonly met with, and when pushed deeply into the meatus, and swollen from imbibition, they get firmly fixed, and are very difficult to extract. Hedinger recommends that oil or glycerine should be used in the attempts to syringe out foreign bodies of this class. If this plan fail, it will be necessary to use, with the utmost gentleness and care, various instruments for their removal, such as a small sharp-pointed hook (Fig. 75), or a stiff needle bent at a right angle near its point; these are fitted with appropriate handles. When used, the hook or needle is to be passed along the upper wall of the meatus, between it and the foreign body, until the apex of the instrument is behind the latter. It is then to be turned round so that the point is directed towards the surface of the foreign body. By raising the handle the point is depressed and enters the substance to be extracted: slight traction of the handle may then prove sufficient. If the foreign body be deeply placed in the osseous portion of the meatus, it is better to pass the hook along the anterior and inferior wall; for if it be passed along the upper surface, there is risk of injuring the superior and posterior portion of the membrana tympani. Two hooks, one on each side of the substance to be removed, are sometimes required. When the handle of the instrument is circular, it is well to have a mark on it, such as the notch on Fig. 75, to denote the direction of the hook.

Instruments with a screw at the extremity are seldom of much use in extracting a foreign body other than wool. They are liable to drive the substance deeper into the ear, and the screw is apt to tear its way out when traction is made. The screw (Fig. 76) is, however, very useful in breaking up peas, beans, and similar soft substances, and enabling them to be subsequently removed by syringing or by other instruments. Forceps are not serviceable for extracting round hard bodies which are firmly fixed in the meatus. If injections fail, a fenestrated curette may be tried (see Fig. 28, p. 83); a wire loop, or a blunt hook, or sometimes a bent probe is the most efficacious instrument. Dr. Ward Cousins has devised the extractor shown at Fig. 77. It consists of two loops, which can be approximated by slipping forward the ring in the centre of the handle. This instrument would be useful for removing beads, buttons, etc. In order to break up a hard body, the use of the galvano-cautery has been suggested, but the effect of heat upon the walls of the meatus is likely to be mischievous. Politzer thinks that it might be tried for such an object as an impacted cherry-stone, in order to burn a hole for the passage of an extraction-hook. Dr. Guye, of Amsterdam, has invented a small forceps[*] for the removal of cherry-stones and similar bodies from the meatus. In the case of a large bead firmly fixed in the meatus, its extraction was accomplished by means of a laminaria tent passed through the aperture. This was allowed to remain for some hours, and when removed, it brought the bead with it.

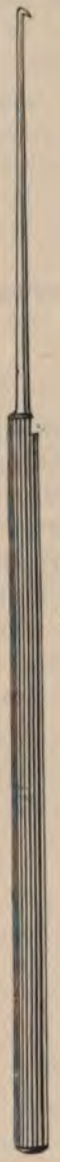


Fig. 75.

Hook for the Extraction of Foreign Bodies.

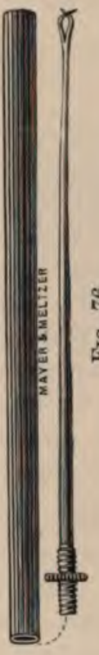


Fig. 76.

Double Screw for the Extraction of Foreign Bodies.

When the membrana tympani is perforated, and also when the foreign body has passed into the tympanum, and other measures have failed, its removal may sometimes be effected by injecting air or fluid through the Eustachian tube.

Cases in which foreign bodies are present in the external auditory meatus differ exceedingly in many particulars, and necessitate different methods of treatment. The nature and shape of the foreign body, its size, and especially its position in the meatus, are the points of most importance. Removal is generally easy if the body be placed in the cartilaginous portion of the canal, and if there be no hæmorrhage or swelling caused by attempts at extraction. On the other hand, difficulties will often present themselves when the foreign body is in the osseous section, and firmly impacted. In the absence of any troublesome symptoms there is no need to expedite the extraction of foreign bodies from the meatus.

---

[*] *Archives of Otology*, vol. xv. p. 32.

When extraction is impossible, and symptoms of cerebral irritation are developing, it is advisable to make an incision behind the ear, and partially separate the auricle from its posterior attachment. In children, the superior wall of the meatus should be detached from its insertion, and a curved hook should be passed from above behind the foreign body. In adults, it is best to detach a portion of the posterior and inferior wall, and attempts should then be made to remove the foreign body with the aid of hooks, bent at various angles, or suitable forceps. After removal, the parts should be carefully readjusted and sutures applied.

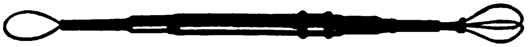


FIG. 77.

WARD COUSINS' EXTRACTOR.

CHAPTER XX.

AFFECTIONS OF THE MEMBRANA TYMPANI.

Injuries of the Tympanic Membrane—Indirect and Direct Causes—Symptoms—Subjective Sensations—Alterations in Hearing-Power—Objective Symptoms—Rupture of the Membrane from Sudden Condensation of Air—Dr. Snell on Caisson Disease—Mechanical Injuries—Rupture of the Membrane by *Contre-Coup*—Prognosis—Treatment—Inflammation of the Membrana Tympani or Myringitis—Symptoms—Abscesses in the Membrane—Formation of Vesicles—Diagnosis—Prognosis—Treatment—Chronic Inflammation of the Membrana Tympani—Causes—Symptoms—Course and Treatment.

INJURIES.

Injuries of the Membrana Tympani constitute about seven per 1,000 of aural affections in general, and are therefore somewhat rare. The membrane is to a great extent protected by its position and mode of attachment to the surrounding bone. It may, however, be torn or ruptured as the result either of *indirect* or *direct* injury. Examples of the *former* kind are (*a*) cases in which the membrane is torn as the result of concussion, due to blows or falls; and (*b*) those in which the mischief is due to the effect of suddenly condensed air, *e.g.*, in violent explosions. Perhaps, however, these latter cases ought to be regarded as examples of *direct* injury, the result of an actual *blow* from the surrounding atmosphere. Forcible condensation of the air in the tympanic cavity has been known to cause rupture of the membrane. Thus the accident is occasionally due to violent coughing, sneezing, and blowing of the nose, and also to the injection of air by Politzer's method and by the catheter. Such a result, however, could scarcely occur in the absence of pathological changes in the affected membrane. *Direct injuries* are caused by foreign bodies coming in contact with the membrane, by chemical agents, and by fractures of the surrounding bone. In very rare instances, the tympanic membrane has been partially destroyed by a burn, with persistent perforation as a result. Cases due to unskilful attempts to remove foreign bodies from the meatus are by no means uncommon. In all cases of injury from violence, pre-existing morbid conditions of the membrane more or less affect the result. Perforation is not infrequently due to intra-tympanic disease. Thus, exudations within the cavity and morbid growths extending outwards are liable to cause absorption of portions of the membrane. Lastly, it must not be forgotten that the membrane is occasionally injured by bougies, passed along the Eustachian tube.

Superficial Injuries, or excoriations involving only the external layer, are often caused by the introduction of hard, pointed bodies for the purpose of cleansing the ear or relieving irritation. Similar consequences are not infrequently caused by attempts to remove foreign bodies from the meatus. Owing to the oblique position of the membrane, injuries of this kind generally affect its upper half and the superior wall of the meatus. The symptoms are for the most part of a mild character, provided that the membrane is not torn through. There is more or less pain, and perhaps a little hæmorrhage, which, however, soon subside.

When the membrane is completely divided, as, for example, by falls upon pointed objects, the symptoms are apt to be severe; they depend upon the nature of the injury, the force employed, and the previous condition of the part. Laceration of a healthy membrana tympani causes sudden and very severe pain; but if there has been any previous disease, with fatty degeneration as a consequence, laceration may be easily produced and cause little pain to the patient. With a membrane previously normal, the pain may be so severe as to cause faintness and even attacks of syncope, and in hysterical subjects convulsions are liable to occur. In most cases, giddiness is an immediate result of the injury; it may be so severe that the patient falls down or staggers like a drunken man. Nausea and vomiting may be superadded; but these symptoms pass off unless the labyrinth be involved. The pain also soon subsides in the absence of inflammation of the membrane; if it continue beyond a few hours, complications may be looked for.

Subjective Sensations.—In addition to those already mentioned, various other subjective sensations are liable to be produced by rupture of the tympanic membrane, and the hearing-power is certain to be more or less affected. At the moment of the occurrence of the injury, a loud noise is usually heard, resembling that of an explosion; this generally lasts for a few seconds only, though it may be replaced by a slighter and continuous sensation. If inflammation be set up, the sound will be altered in character. The loud noise, first heard, is due to the rupture of the fibres; it resembles that which is caused when a tense membrane gives way. The subsequent and continuous noises may be due to several causes, *e.g.*, effusion within the tympanum, hæmorrhage in the labyrinth, or concussion of the auditory nerve. The noises heard after inflammation has set in are dependent upon the alterations produced in the tympanum. When rupture of the membrane is caused by condensing the air in the cavity (as in employing Politzer's method), the crack can generally be heard by the surgeon.

Various alterations in hearing-power are immediate results of the injury; the form they take depends upon the nature of this latter and on the previous condition of the membrane. Auditory hyperæsthesia is an occasional result, sometimes evinced towards sounds in general and sometimes towards special notes. In the majority of patients, however, there is marked diminution of hearing-power, and this rule obtains whenever the membrane was previously normal. It is rare for the diminution to be so great that a watch can be heard only when in contact with the auricle. When this symptom is present, lesion of the internal ear may be inferred to exist. In all such cases the other ear should be carefully examined, in order to compare the hearing-power.

When the injury has been inflicted upon a membrane altered by disease, the effect upon the hearing-power may be of an altogether different character. When the membrane was previously in a state of abnormal tension or adherent to the walls of the cavity, its condition may be so changed by the force which caused the rupture, that temporary improvement in hearing power may actually result, though as a matter of course aggravation of the disability is only too likely to occur.

Another symptom is sometimes noticed in cases of injury of the tympanic membrane; the power of distinguishing the direction whence sound comes is impaired or altogether lost on the affected side. The power is apt to be restored before the wound in the membrane is healed. Some patients complain of a sensation of fulness and pressure in the ear; these symptoms are probably due to effusion within the tympanum or between the layers of the membrane. Blowing the nose sometimes causes a hissing sound, due to the air which escapes through the opening.

The **Objective Symptoms** vary with the cause and extent of the injury. The membrane is more or less reddened and swollen, but when the rupture has been caused by a sharp instrument, only the edges of the wound may present these appearances. With regard to their seat, perforations due to indirect force are usually found in the posterior inferior quadrant and towards the central portion of the membrane; the peripheral part is thicker and more capable of resisting force applied to it. Sometimes the edge of the perforation corresponds with that of the handle of the malleus, and the margin of the wound is not infrequently excoriated. There is seldom more than one opening, and it is generally roundish in form. It varies in size between a mere fissure or cleft (which looks dark when seen through the speculum), and a gap involving the greater part of the membrane. In rare cases, from two to five perforations have been caused by indirect injuries. When the edges of the wound are far apart, they are often covered with coagulated blood, and this may be so firmly adherent as to be very difficult of removal. Portions of the membrane at some distance from the opening are sometimes covered with ecchymoses. In some cases, the layers of the membrane are unequally involved in the injury, and whenever a blunt instrument has been used, the margins are apt to be irregular. The amount of blood in the meatus depends upon the extent and character of the wound; in the absence of complications there is seldom profuse hæmorrhage. When the perforation is very large, it may be possible to see the mucous membrane of the tympanum. In all cases of rupture of the tympanic membrane, purulent inflammation of the middle ear is likely to set in, and especially if the syringe has been used to wash out the meatus. There is far less risk in the use of the air-douche, which may, if necessary, be employed for diagnosis. For this purpose, however, it is better to use a catheter, as by its means the pressure of air can be more easily regulated.

A punctured wound of the tympanic membrane may be complicated by escape of cerebro-spinal fluid. Thus, in a case reported by Professor Schwartze,* a knitting needle passed through the membrane in the region of the stapes, and the injury was followed by transient syncope, vomiting, no hæmorrhage, but escape of cerebro-spinal fluid from the ear. This flow lasted for eight days, and was so profuse as to cause continuous trickling. The most violent headache, earache, and vertigo at once set in, and were followed by other symptoms of cerebral irritation, which lasted for four weeks. It was doubtful whether there had been a lesion of the labyrinth from the penetration of the needle into the fenestra ovalis, or into some other part of the wall. It was also possible that the cerebral fluid might have been evacuated through the tegmen tympani, after its perforation by the needle, with simultaneous rupture of the mucous membrane and the dura mater. In a case referred to by Brieger,† there was free communication between the vestibule and tympanum, together with separation of the anterior crus of the stapes from the foot-plate. These conditions were discovered on post-mortem examination three years after the injury to the ear.

Injuries involving rupture of the tympanic membrane are sometimes associated with fracture of the ossicles, especially of the malleus, and lesions of the deeper structures. Union of the fractured ends is the rule in such cases; but the normal position of the parts is seldom preserved.

Owing to its deep-seated position, the tympanic membrane is seldom injured as a result of concussion from falls or blows, unless the bone be simultaneously fractured. Cases of perforation of the membrane are sometimes attributed to blows or shocks; but it will generally be found that some diseased condition of the membrane has previously existed.

Effects of Condensed Air.—Rupture of the membrane may undoubtedly be caused by sudden condensation of air in the

---

* *Archives of Otology*, vol. xi. p. 82.

† *Klinische Beiträge zur Ohrenheilkunde*, S. 39.

external meatus, produced either by blows upon the ear,* or by explosions of gunpowder. Dr. Barr † records a case in which the impact of a tennis ball upon the tragus caused rupture of the tympanic membrane. Such cases are, however, extremely rare, and in most of the recorded instances there was a history of previous disease of the membrane. Gruber ‡ relates the case of an officer who was struck down at Königgrätz by the bursting of a shell. On recovering consciousness, he became aware of a loud noise in the left ear. There was also deafness on that side, moisture in the meatus, and escape of air when he blew his nose. A few hours afterwards pain set in, and other symptoms of inflammation. On examination, a roundish opening was discovered in the anterior inferior segment of the membrane; there were no evidences of any previous disease, and the structures of the other ear were quite normal. This was the only case of rupture of the membrana tympani that was reported during the war, in which many hundreds of the soldiers who were engaged doubtless suffered from some disease of the ears. Deafness is not uncommon among artillerymen, but it is only in very rare cases that perforations of the membrane have been discovered, and these are more likely to have been caused by disease than by explosions. Dr. Sexton,§ however, had the opportunity of examining the ears of eight men who had been in the vicinity of an exploding shell. In six men the membrana tympani was found to be ruptured; in some, rather extensively. In all, there was serious impairment of hearing. In the cases of persons who have become deaf as a result of sudden condensation of air, the condition is generally due to lesion of the nervous structures. As a result of various morbid processes, the membrane may become comparatively fragile, and will then give way under the operation of slight causes, as during coughing, straining, blowing the nose or sneezing. In some cases of this character, the rupture is followed by the escape of muco-purulent fluid from the meatus, thus demonstrating the existence of disease in the tympanum.

Dr. Roosa ‖ states that in America, during the late Civil War, only one case of rupture of the tympanic membrane occurred from the explosion of artillery. He has also met with one case in which firing of a pistol near the ear produced this result. In the explosion of dynamite which occurred in the Transvaal* in 1896, the list of wounded included many cases of "ruptured tympanum, with hæmorrhage from the ears." The development of an enormous volume of gas produced an instantaneous and terrific increase of pressure. Lyddite acts in the same way, and many cases of ruptured tympanic membrane have probably occurred from shell-explosions during the present war.

---

* See summary of a paper by Dr. Sexton, *Archives of Otology*, vol. xvi. p. 360, and a paper by Dr. Treitel, *Ibid.*, vol. xix. p. 110.

† *Manual of Diseases of the Ear*, p. 200.

‡ *Lehrbuch der Ohrenheilkunde*, S. 311.

§ *Archives of Otology*, vol. xvi. p. 360.

‖ *Diseases of the Ear*, Seventh Edition, p. 260.

Injury to the membrane is sometimes due to another cause, viz., "the force of condensed air found in passing through the lock of a caisson used in excavating for the foundations of bridges, or the making of tunnels under rivers." In most of such cases, however, the permeability of the Eustachian tubes had been previously impaired by disease. The injury is caused by the pressure of the condensed air upon the membrana tympani; if the external meatus be hermetically plugged, no unpleasant sensation is experienced. The rupture may be caused directly by the pressure; but in another class of cases, congestion and inflammation of the membrane are the first effects, and perforation ensues later on. If those engaged in the work adopt from time to time Politzer's or Valsalva's method of inflating the ears, all bad consequences will be prevented.

In an exhaustive monograph based on cases observed during the making of the Blackwall Tunnel, Dr. Hugh Snell† has given an elaborate account of the various symptoms, some of which are very remarkable and are by no means confined to the ear. The injuries sustained by the latter organ occur during the process of entry to the compressed air. If, however, the aural structures be normal, the Eustachian tubes patent, and the workmen have acquired the knack of opening the tubes to allow the entrance of additional air to the middle ear, no inconvenience is experienced; and this is the general rule. But if the tubes be more or less occluded, the tympanic membrane will be pressed inwards, and some amount of pain will be felt. If this warning be neglected, the pain may become excruciating, "and rupture of the drum may occur; this event may happen without any excessive pain, if the drum be less resisting than normally." Should the membrane be uninjured, the relative vacuum in the middle ear is liable to act as an effective cupping-glass, and to produce congestion of the lining walls of that cavity. This may last for several days and be accompanied by more or less deafness on that side. The congestion may also be followed by actual inflammation, with or without suppuration.

---

* *Brit. Med. Journ.*, 1900, vol. i. p. 281.

† *Compressed Air Illness, or so-called Caisson Disease*, 1896.

"Diminished acuteness of hearing was noticed in many of the men who had worked in compressed air for a long period. It is probable that frequently recurring congestion ultimately produces a thickening of the lining of the membrana tympani and of the ossicles, and consequent impairment of hearing." Other symptoms sometimes observed are auditory tinnitus and vertigo, and such cases more or less closely resemble those of Ménière's disease.* Besides the ear-symptoms, the men often complain of pain in the forehead and in the extremities, most often in parts about the knees. This, called by the men "bends," is the most common symptom. Epigastric pain, paralysis, unconsciousness, dysphagia, epistaxis, and hæmoptysis are occasionally noticed.

The ear-mischief can be prevented by careful inflation of the ears; and no man should be allowed to enter the pressure when there is any pain or discomfort in those parts.

Mechanical Injuries to the head, causing fracture of the temporal bone and of the base of the skull, may of course produce rupture of the tympanic membrane. The prominent symptom of such an injury is hæmorrhage from the meatus, or more or less serous discharge from the ear. The membrane may, however, escape even in severe fractures of the temporal bone, attended by considerable hæmorrhage. The latter symptom is sometimes indicative of rupture of the lateral sinus, but the blood may come from the tympanic artery. When the injury is immediately followed by the escape of clear, slightly albuminous fluid from the meatus, there is reason to suspect fracture of the petrous portion of the temporal bone, involving the roof of the tympanum, and the osseous part of the external meatus, with laceration of the cerebral membranes and rupture of the membrana tympani.

---

* See also summary of a paper by Ferdinand Alt, in *Archives of Otology*, vol. xxvi. p. 81. Three cases are reported in which symptoms of Ménière's disease began half an hour to two hours after leaving a caisson, where the pressure had been equal to 2·5 atmospheres.

If the discharge first appear twenty-four hours or more after the injury, it is in all probability not cerebro-spinal fluid, but inflammatory exudation produced within the tympanum. In a fracture involving the petrous portion of the temporal bone, and attended by the above symptoms, paralysis of the muscles supplied by the facial nerve may be expected to occur. Loss of taste on the same side of the tongue may also result from injury to the chorda tympani. Sometimes the mastoid portion is involved, while the base of the skull escapes. Thus, in a case recorded by Kirchner,* there was injury to the tympanic membrane, and consequent inflammation of the cavity, and, in addition, a fissure in the osseous meatus, extending into the mastoid portion, with subsequent necrosis. Sinus-thrombosis is another possible consequence of such injuries.

Rupture of the membrana tympani on each side is a very rare accident, and is generally accompanied by fatal injuries of other parts. In one case, however, reported by Dr. J. M. Ray,† both membranes were ruptured from a fall on the head. Hæmorrhage from the ears went on for four days, and then gave place to a straw-coloured fluid. Notwithstanding the serious character of the injuries, the patient made a good recovery, and was reported "well" three months after the accident.

Rupture of the membrana tympani sometimes occurs by *contre-coup*—that is to say, the injury to which it is due is inflicted on a part of the head at some distance from the membrane. Thus falls on the forehead, vertex, and occiput have caused an injury of this character. Such cases are less common than those in which the injury is on the same side of the head as the blow. In one instance recorded by Dr. C. Williams,‡ of Minnesota, the injury consisted of fracture of the left external auditory canal and rupture of the membrana tympani. The patient, a man aged thirty-seven, had fallen backwards on a slippery path, and struck the back of his head against the ice with such force as to produce unconsciousness, which lasted for some time. That the back of his head was the part struck was shown by the fact that the corresponding portion of "his stiff felt hat was broken off and lay under his head." In a case under the care of Dr. Eitelberg,* of Vienna, after a fall down some steps, the greater part of the tympanic membrane on the right side became detached and came away. Two months later, the loss of substance was entirely replaced.

---

* *Arch. f. Ohrenheilkunde*, Bd. xix. S. 261.

† *Archives of Otology*, vol. xv. p. 192.

‡ *Ibid.*, vol. xiii. p. 157.

Prognosis.—In rupture or traumatic perforation of the membrana tympani, the prognosis depends upon the nature of the injury, the presence of complications, and the previous condition of the ear. In many cases, ruptures of the membrane, due to traumatic causes, heal up in a few days, the process being effected either by adhesion of the margins of the wound, or by the development of membranous tissue between them. The hearing-power is but little, if at all impaired. Ecchymoses of the membrane are apt to change their position in the course of time, and to pass towards the periphery. In their later stages, they are often found at the upper and posterior part, and project slightly from the surface. Sometimes yellow spots remain, due to metamorphosis of the hæmoglobin. The subjective sensations generally pass away after the perforation has closed.

When the injury has affected the labyrinth, the prognosis must be guarded. Restoration of the hearing-power is likely to be incomplete. In the presence of such complications as injuries to the osseous walls, dislocation or fracture of the ossicles, complete recovery is not to be expected; the hearing-power is certain to be seriously impaired, if not altogether lost. Purulent inflammation of the middle ear sometimes results from injuries to the membrana tympani. It is not infrequently caused by the injudicious treatment of such cases. The symptoms of such a complication are increase of pain in and about the ear, elevation of temperature, and marked hyperæmia of the membrane. The opening becomes larger, and more or less purulent secretion escapes. In unfavourable cases, portions of the membrane are destroyed, granulations or polypi form, and the process becomes one of chronic suppuration of the middle ear, with all its dangers.

In complicated cases, the tuning-fork sometimes aids in determining the extent of the injury. If the bone-conduction on the affected side be better than conduction through the air, injury to the labyrinth may be excluded.

The general health of the patient will influence the prognosis.

---

* *Archives of Otology*, vol. xix. p. 12.

In tuberculous subjects, healing of a perforation is often very incomplete.

Treatment.—As a general rule, slight injuries to the tympanic membrane quickly become healed. All that is necessary is to introduce into the meatus a small plug of cotton-wool carrying a little carbolised oil, and to apply a bandage so as to protect the ear. Simple ruptures of the membrane require similar treatment. The patient should be kept quiet, and should avoid doing anything likely to cause cerebral congestion. Forcible sneezing and blowing the nose violently are certain to interfere with the healing process. The desire to sneeze may sometimes be checked by rubbing the bridge of the nose with the finger. Any little masses of coagulated blood and foreign bodies in the meatus should be carefully removed with the forceps or scoop, and the parts should be cleansed with a little cotton-wool attached to a probe; the instillation of fluids and syringing are never advisable. Such procedures are only too likely to cause severe inflammation of the membrane and tympanum. If there be severe pain in the ear, and hyperæmia of the membrane, a few leeches may be applied with advantage either over the mastoid process or in front of the tragus. Cold applications are also likely to be serviceable. After all active symptoms have subsided, if the discharge from the ear become sero-purulent, warm antiseptic solutions should be cautiously tried. Other details will be found in the chapter on Chronic Suppuration of the Middle Ear.

INFLAMMATION OF THE MEMBRANA TYMPANI—MYRINGITIS.

Primary acute inflammation of the membrana tympani very seldom occurs; but the membrane is liable to be implicated in various inflammatory processes of the external and middle ear. The majority of cases of acute myringitis are of a secondary character. Inflammation of the meatus, due to fungi, is apt to spread to the membrane, with perforation as an occasional result in neglected cases.

Primary acute myringitis is almost invariably confined to one ear, and follows directly upon some form of injury. The most common causes of this character are: foreign bodies, the application of irritating or caustic fluids, and exposure to cold. Mr. Field believes that inflammation of the membrane, with subsequent perforation, may be caused by the action of sea-water, and that the attack is really due to micro-organisms contained in the fluid, which is often contaminated by sewage.

Symptoms.—In acute cases, especially when due to direct injury, the first symptom is more or less severe pain, of a pricking or tearing character, which increases in intensity, and subsides with the appearance of a serous discharge. The patient also complains of a feeling of pressure and fulness in the ear, and of noises of various kinds, often of a pulsating character. Hearing-power is somewhat lessened. More or less fever is generally present, and delirium may occur in young subjects. The pain and the other symptoms are usually worse at night.

The **Objective Symptoms** depend upon the exciting cause and the degree of inflammation, and likewise upon the previous condition of the membrane. In most cases the membrane is not uniformly affected; but the signs of inflammation are especially marked in the upper portion and along the handle of the malleus. The principal changes occur in the external layer of the membrane, which becomes hyperæmic and yellowish-red in colour; these appearances commencing near the handle of the malleus, and gradually becoming diffused over the whole surface. In a subsequent stage, which rapidly supervenes, the membrane, especially in its upper part, becomes opaque and much swollen, so that it projects into the canal. The handle of the malleus is no longer distinguishable, being covered up by the infiltrated tissue; its position is marked by injected vessels. Beneath the epidermis, more or less sero-purulent fluid is exuded, and sometimes vesicles are distinguishable. During the further progress of the case, separation of the epidermis is a marked feature, and the exudation becomes more copious and purulent. The deep portion of the external meatus is reddened and swollen, sometimes to such a degree as to obliterate the periphery of the membrane, which may be still further covered up by accumulated secretion.

In the subsequent course of the disease, after detachment of the epithelium, the exudation gradually diminishes in quantity, and the swelling subsides. Some weeks, however, pass before the signs of inflammation eventually disappear. The redness becomes less and less marked, and the normal translucency and lustre of the membrane are gradually restored, unless fatty degeneration or partial calcification has occurred.

Abscesses in the Membrane.—In rare instances, instead of exudation beneath the epidermis, abscesses form in the substance of the membrane. Such formation is most often seen in the early stages of middle-ear inflammation. In those cases in which vesicles and abscesses are developed without obvious cause, they may possibly be dependent upon irritation of nerve-centres, and thus resemble herpetic eruptions. Their formation is attended by more or less severe pain; but the subjective sensations and loss of hearing-power are for the most part slight. Such abscesses are generally found in the posterior superior quadrant, and extend from the membrane to the wall of the meatus. They contain clear yellowish exudation; are more or less rounded in form, and are surrounded by a reddened margin in which enlarged vessels are distinctly visible. They usually burst externally, leaving small, flat, yellowish-red ulcers, which have a tendency to perforate the membrane. Sometimes, however, the contents of the abscess become absorbed, and the process comes to an end with the detachment of a yellowish crust. Partial calcification is sometimes observed, and one or more whitish chalk-like patches are seen on the membrane. Such a result is not infrequent in the case of abscesses of the membrane connected with acute middle-ear inflammation. The deposition of tubercle sometimes leads to the formation of abscesses, with perforation as a consequence.

Formation of Vesicles.—Acute inflammation of the tympanic membrane occasionally gives rise to other changes than those already noticed. In one variety described by Politzer* as *myringitis bullosa*, in addition to increased vascularity near the handle of the malleus, and scattered ecchymosed patches, one or more transparent vesicles, as large as hemp-seeds, pearly white in colour, and filled with serous fluid, appear on the surface. These vesicles either burst, or disappear owing to the absorption of their contents.

In another form, which has of late been somewhat frequently observed in connection with influenza,† ecchymosed patches are accompanied by the development of bluish-black, tense vesicles, containing blood, which are apt to extend to the wall of the meatus and to bleed very freely on bursting. Their development is accompanied by very severe pain. The origination of these vesicles is attributed to capillary thrombosis, said to be due to a peculiar micro-organism found in the blood of influenza patients.

---

* *Lehrbuch der Ohrenheilkunde*, II. Aufl. S. 192.

† Gruber, *Allgem. Wiener Med. Zeitung*, 1890, No. 10.

Diagnosis.—The diagnosis of acute inflammation of the membrana tympani is seldom difficult; the complaint may, however, be confounded with acute middle-ear inflammation. In myringitis, the impairment of hearing is slight in comparison with the objective appearances; the air-douche causes pain, but no abnormal sound on auscultation. The pain is relieved by pressing the finger gently into the ear. When abscess exists, it may be detected with the probe; its surface will be found to pit on pressure. It must be remembered that acute inflammation of the tympanic membrane is very seldom of primary origin, whereas it frequently accompanies acute suppuration of the middle ear.

Prognosis.—The prognosis in cases due to injury varies with the degree of the inflammation and the general condition of the patient. If the injury be slight and the patient's health good, recovery within a few days is the general rule. If, however, there be any constitutional dyscrasia, *e.g.*, tuberculosis, the complaint may prove very obstinate and tedious.

In severe cases, perforation is not uncommon, and this when not caused by the injury may be due to a gradual process of absorption or to ulceration, and openings may take place at one or more spots. Abscesses formed in the membrane generally burst externally, but the pus may break through into the tympanum as well, with a large perforation as the result. In other cases, a different course may be noticed; the pus becomes partly absorbed, and in process of time is converted into a calcareous mass. Atrophy of the membrane is a common result of inflammation; but in some cases, thickening or hypertrophy remains behind.

Treatment.—Careful treatment is required not only to relieve pain, but to prevent injurious consequences. The first step is to protect the meatus and membrane by the introduction of a plug of cotton-wool. Injections of any kind are not to be recommended, inasmuch as they are liable to act as irritants and increase the hyperæmia. For the relief of the latter, several leeches should be applied below the ear and over the mastoid process. In severe cases a small bladder of powdered ice may be placed over the ear, care being taken to prevent water from trickling into the meatus. If the leeches fail to relieve the pain and hyperæmia, it is well to try the effect of a few superficial incisions through the integument of the deep part of the meatus, as recommended by Gruber. These should be about $\frac{1}{8}$-inch long, and parallel to the margin of the membrane, so as to divide some of its blood-vessels. The bowels must be relieved by means of saline purgatives. If the pain prove very severe, lukewarm water containing anodynes in solution may be dropped into the ear; of these, cocaine is the most efficacious, used in the form of a 10—20 per cent. solution. When an abscess has formed in the membrane, it should be opened as soon as possible with a myringotome.

As the acute inflammation subsides, serous fluid escapes from the ear, and the pain is much mitigated. The meatus may then be syringed out thrice daily with a 3 per cent. solution of boric acid, after which a plug of cotton-wool charged with perchloride of mercury is to be introduced. The ear should be carefully examined in order to see whether perforation exists. This may be difficult to detect at first, inasmuch as the swollen and softened state of the membrane prevents an aperture from gaping. The best evidence is obtained by employing Politzer's method, or the Eustachian catheter. If a perforation exist, the air passing through it will give rise to a blowing, whistling sound.

Another sign of perforation is to be found in the discharge from the ear. When the tympanic mucous membrane is involved, the matters discharged will be mucous in character, and hence if after the use of the syringe threads of mucus are found in the fluid, the existence of a perforation may be inferred. Later on the secretion becomes purulent in character. As a matter of course, involvement of the tympanum lengthens the duration of the case, and influences the prognosis. Adhesions of the sound-conducting parts are certain to take place, with more or less impairment of hearing as a necessary consequence.

CHRONIC INFLAMMATION OF THE MEMBRANA TYMPANI—CHRONIC MYRINGITIS.

Chronic inflammation of the membrana tympani is generally the result of an acute attack, and may continue for weeks or even for months. It is, however, but rarely an independent affection; in most cases it occurs in connection with inflammation of the middle ear or of the meatus. Even if the morbid process commence in the membrane, perforation is the ordinary result in chronic cases, with subsequent implication of the tympanic cavity. When both parts are involved, it may be impossible to determine the course and starting-point of the disorder.

The **Symptoms** of chronic myringitis are less marked than those of the acute disorder. They consist of noises in the ears, a sensation of fulness and pressure, more or less deafness, with itching or sharp pricking pain from time to time. The discharge from the ear is muco-purulent and variable in quantity, being sometimes very abundant, and sometimes very scanty. On examining the meatus, the deeper parts are seen to be swollen, red, and covered with epithelial débris. The membrane itself is grey or greyish yellow, thickened, and devoid of transparency; the short process and the handle of the malleus are indistinguishable. The surface of the membrane may be covered by exudation in the form of crusts. Ulcers and granulations are sometimes present, and the latter, in the course of time, may attain the size of a pea, and project like a polypus into the meatus; their presence does not necessarily indicate perforation of the membrane. Ulceration of the membrane is sometimes due to syphilis.

Chronic myringitis is not always associated with purulent discharge from the meatus. When the membrana propria is especially involved, increase of the connective tissue is the general result. This produces thickening and rigidity of the membrane, with considerable impairment of its functions.

A villous condition of the membrane has been noticed, as a result of chronic inflammation. Small projecting growths of connective tissue, inclosing a capillary loop, and covered with pavement epithelium, occupied the surface of the membrane, while the membrana propria was much thickened.* Such villous growths resemble mucous polypi; in some cases the adjoining part of the meatus has been found similarly covered. In all these forms of chronic inflammation, the whole membrane may be affected, or only certain portions thereof, leaving intermediate spaces free.

---

* *Arch. f. Ohrenheilkunde*, Bd. V. S. 250.

Course of the Disease.—Chronic inflammation of the membrana tympani runs a very tedious course, and rarely ends in complete recovery; thickening, opacity, and calcareous deposits often remain, and in other cases there is atrophy with perforation. The chronic stage which often follows acute inflammation is sometimes characterised by oft-repeated desquamation of the epidermic layer. In such cases the discharge mainly consists of thick yellowish-white flakes of epithelium, with a little purulent fluid. The membrane is covered with epithelial scales, and sometimes dotted over by minute granulations.

Treatment.—In comparatively slight cases the meatus should be carefully syringed in order to remove purulent secretion and epithelial débris, both of which irritate the parts, and maintain the hyperæmic condition. After syringing and careful drying, powdered boric acid may be applied by means of an insufflator. If this prove insufficient, recourse may be had to solutions of zinc sulphate (gr. iij. to ℥j.), of which a few drops warmed may be poured into the ear once daily. A solution of acetate of lead, of similar strength, may also be tried. In the desquamative form, the crusts should be softened by dropping in a solution of carbonate of sodium (1 to 5 each of glycerine and water). The ear is then to be syringed, after which astringents (zinc or lead) will prove useful. In very obstinate cases, a 2 per cent. solution of nitrate of silver may be used with advantage. When granulations and ulcers exist on the membrane, they should be touched with a solution of chromic acid, or with solid nitrate of silver, or with its solution (10 per cent.) applied by means of a brush, or absorbent wool twisted on to the end of a probe. It is well to syringe the ear after applying the caustic, which may be repeated every third or fourth day. For the destruction of granulations, a solution of chromic acid will generally be found more efficacious than the nitrate of silver; it is to be carefully applied on a chromic acid carrier or wool every three or four days. It is very seldom necessary to use the galvano-cautery for the destruction of granulations; but Politzer recommends a simple platinum point, and that each cauterisation should last only two or three seconds; the circuit is to be closed when the growth is touched by the electrode, which must be withdrawn after each application. The pain caused may be somewhat lessened by the previous application of a 5—20 per cent. solution of cocaine.

Various conditions of the tympanic membrane, associated with middle-ear suppuration, will be described in subsequent chapters.

CHAPTER XXI.

DISEASES OF THE NOSE, PHARYNX, AND NASO-PHARYNX, CONNECTED WITH DISEASES OF THE MIDDLE EAR.

Influence of Diseases of Nose and Naso-Pharynx on Condition of Tympanum—Acute Nasal Catarrh—Causes and Symptoms—Extension to Eustachian Tubes—Objective Appearances—Treatment—Chronic Catarrh of the Naso-Pharynx—Causes and Anatomical Appearances—Condition of the Mucous Membrane—The Secretions—Symptoms Caused by Swelling of the Mucous Membrane—Nervous Disorders—Course and Changes sometimes produced in Mucous Membrane—Ulcerative Processes—Connection between Chronic Naso-Pharyngeal Catarrh and Aural Diseases—Treatment—Local Applications—The Nasal Douche—The Syringe—Politzer's Method of Applying Solutions to the Nares—Use of the Spray-Apparatus—Inhalation—Ointments—Caustics in Solution—Insufflation of Fine Powders—Nasal Bougies—The Galvano-Cautery—Chemical Caustics—Treatment of Ozæna—Treatment of Enlargement of Posterior Extremity of Inferior Turbinated Body—Treatment of Nasal Polypus—Treatment of Enlarged Tonsils—Granular Pharyngitis—Morbid Growths in the Naso-Pharynx and their Treatment—Removal of Tip of Uvula—Measures for Restoring the Functions of the Muscles of the Tubes—Adenoid Growths—The Pharyngeal Tonsil—Literature on the Subject of Adenoid Growths—Their Anatomical Structure—Etiology—Symptoms, Subjective and Objective—Disorders of Middle Ear Resulting from these Growths—Methods of Examination—Digital Examination—Inspection with the Mirror—Diagnosis—Treatment—General Anæsthesia in Nasal and Naso-Pharyngeal Operations—Cases necessitating General Anæsthesia—Preparation of the Patient—Selection of the Anæsthetic—Posture of the Patient—Administration of the Anæsthetic—Additional Appliances—Management of the Patient after the Administration—Method of Removing Adenoid Growths.

Owing to the anatomical relations of the parts and the manner in which they are connected by means of the Eustachian tubes, diseases of the nose and naso-pharynx are in many cases the starting-points of disorders of the tympanum, and they exercise a very decided influence upon the course and termination of the latter complaints. Thus, catarrh of the naso-pharynx may extend through the Eustachian tube, and produce a similar condition, and possibly one of greater severity, in the middle ear. Moreover, when there is no extension of the original process beyond the Eustachian tube, the obstruction may prevent the proper interchange of air in the tympanic cavity, with catarrhal and other changes as probable results. Any condition which seriously interferes with nasal respiration tends to produce injurious effects in the tympanic cavities.

A knowledge of nasal and naso-pharyngeal disorders is therefore necessary for the treatment of aural affections, and the present chapter will be devoted to a consideration of such diseases as are closely connected with the subject of this work.

The methods of examining the nose and naso-pharynx by anterior and posterior rhinoscopy have been already described (see p. 107 *et seq.*). Digital examination may be necessary for the purpose of discovering the existence and extent of adenoid growths, a fruitful source of middle-ear disease.

The affections of the nose which require description are: acute and chronic nasal catarrh, morbid growths of various kinds, and adenoid growths.

Acute Nasal Catarrh.—This well-known complaint is generally attributed to catching cold; it is most common when the temperature exhibits sudden changes, and sometimes prevails as an epidemic. Nasal catarrh often attacks in succession several members of one family, and in such instances it is highly probable that micro-organisms (streptococci) play an important part in causation. Such organisms are often to be found in the naso-pharynx, where they appear to cause no disturbance so long as the tissues are in a normal condition. When, however, local disorder of circulation is set up as a result of cold and damp, the micro-organisms are capable of exerting a specific influence. Some persons are especially liable to nasal catarrh, while others are seldom affected. Sometimes the cause is purely local; thus, ulcers in the nose, foreign bodies and tumours of various kinds, are apt to cause catarrh, and in the same category must be placed those cases in which the symptoms are due to inhalation of powdered ipecacuanha, and of the pollen of various grasses. Iodine taken internally often causes nasal catarrh, and the same symptom is frequently observed in connection with acute and chronic infectious disorders.

Symptoms.—These are so well known as scarcely to require description. In severe cases there are generally febrile symptoms accompanied by headache, pains in the limbs, loss of appetite, and depression. The local symptoms take the form of a feeling of dryness and a pricking sensation in the nose, while smell and taste are impaired or perverted. In from twenty-four to forty-eight hours a thin watery secretion is poured out, and becomes more and more plentiful; the fluid is of an irritating nature, and often causes more or less inflammation of the orifice of the nose and upper lip. After two or three days the secretion becomes purulent and thick, and crusts form.

The tendency of the catarrh to spread to adjacent cavities is a point of special importance. Thus, it often involves the frontal sinuses and the antrum, and extends backwards to the mucous membrane of the throat. The Eustachian tubes are very liable to be involved, the patients complaining of deafness, pain or fulness, and noises in the ears. The mouths of the tubes are swollen and covered with mucus, and this condition may spread along the canals, and involve the tympanic cavity on one or both sides. Catarrh of the tympanum often results from a similar affection of the naso-pharynx.

Objective Appearances.—On examining the nose, the mucous membrane is observed to be reddened, and covered with secretion; in severe cases there are often erosions and discharge of blood. When posterior rhinoscopy is practised, the pharyngeal tonsil is found to be enlarged, and stands out prominently; and as a result of swelling of the adenoid tissue, Rosenmüller's fossa appears filled up, while the pharyngeal orifice of the tube on one or both sides is reduced to a mere cleft, and is covered with secretion. The posterior wall of the pharynx is reddened and swollen in places, and the surface of the soft palate has an uneven, granular appearance. The mucous membrane of the posterior extremities of the inferior turbinated bodies sometimes projects from the posterior nares in the form of gelatinous greyish tumours, which may extend as far as the pharyngeal orifices of the Eustachian tubes. The septum is often thickened, and in contact with the turbinated bodies, so that the nares are much reduced in width.

Treatment.—In most cases, acute naso-pharyngeal catarrh runs a tolerably definite course, and comes to an end in from ten to fourteen days without any particular treatment. It is especially necessary that the patient should avoid the causes of the complaint, such as exposure to cold and draughts; and this precaution is very desirable for patients who are prone to suffer from ear-symptoms during the progress of the catarrh. In order to mitigate the severity of the symptoms, the patient may be directed to inhale the vapour of water charged with ammonia or carbolic acid; the application of a 2—5 per cent. solution of cocaine to the mucous membrane tends to diminish temporarily the swelling and discomfort. The oft-repeated inhalation of menthol sometimes affords great relief. In some patients, camphor inhaled or taken internally has a decided influence on nasal catarrh. It is useful only at the beginning of an attack, which it sometimes cuts short; or, should it fail to do this, it diminishes the violence of the symptoms. When the irritation is very great, and the pain in the forehead is severe, relief may be procured by insufflating morphine in fine powder, about an eighth of a grain at a time mixed with one grain of starch. Some patients derive great benefit from a few grains of Dover's powder taken at bed-time for three or four nights; other diaphoretics, warm baths and purgatives, are all serviceable in different cases. If the throat be considerably involved, a borax gargle or spray containing the same drug will tend to relieve the catarrh. The best remedy, however, for most cases, is the ammoniated tincture of quinine taken in drachm doses every three or four hours, to which may be added some salicylate of soda and a little opium. A double dose should be taken immediately the early symptoms are noticed, and a single dose continued at the intervals mentioned above.

Chronic Catarrh of the Naso-Pharynx may succeed the acute disease, or it may become gradually developed as an independent disorder. In the former case it is most often seen in debilitated or cachectic persons who have suffered from some acute infectious disorder, or are the subjects of pulmonary disease. It may last for months or even years, improvements alternating with relapses. In some patients the condition of the naso-pharynx is maintained and aggravated by the nature of their occupation. Many instances of this kind are to be met with among omnibus drivers, cabmen, engine drivers, furnace-men, cooks, and others exposed to great changes of temperature, or those who have to work in dust or irritating vapours. The immoderate use of alcohol and tobacco too often helps to intensify and perpetuate the naso-pharyngeal complaint. Gastric derangement is a frequent source of this affection, and nasal obstruction due to any cause is also an important factor in maintaining this disease. In children the presence of intestinal worms may cause the continuance of this malady. Enlarged tonsils and an elongated uvula also act as sources of irritation.

Anatomical Appearances.—The changes are not confined to the naso-pharynx, but almost invariably extend to the accessory cavities and adjacent parts. When the condition has existed for some time, the Eustachian tubes and tympanic cavities are rarely found to be normal. On examining by posterior rhinoscopy, the parts are seen to be relaxed and swollen; the pharyngeal tonsil, the orifices of the Eustachian tubes, the middle and inferior turbinated bodies, the soft palate and the uvula are the parts especially involved. An œdematous condition is not infrequent. The colour varies; it may be pale red, greyish red, or brownish red. In drunkards the naso-pharynx is often of a deep red colour, and the mucous membrane presents many tortuous dilated vessels and small patches of extravasated blood. In severe cases of this kind, and especially when complicated by hepatic or cardiac disease, copious hæmorrhage from the throat is a not infrequent symptom.

In chronic naso-pharyngeal catarrh, the swollen condition of the mucous membrane is due to vascular dilatation, serous infiltration, and deposits of cellular elements in the connective tissue, with hypertrophy and induration as further results. Retiform or adenoid tissue, in some places diffused, and in others forming small masses, is very abundant in the naso-pharynx, and rapidly increases under the influence of irritation. The enlarged lymphoid follicles project above the surface of the mucous membrane, and give rise to the appearances peculiar to granular or follicular inflammation. The swollen condition of the nasal mucous membrane is liable to frequent variations, in great measure due to the existence of the cavernous tissue in the submucous layer of the membrane covering the turbinated bones, and especially the inferior. Patches of this tissue are often in a varying state of engorgement during catarrh, and are also liable to chronic induration. Such changes are apt to be most marked in the posterior extremity of the inferior turbinated body, which then projects into the posterior nares, and occupies more or less space in the upper part of the pharynx. The treatment of this condition will be referred to presently.

Changes in the Secretion.—In cases of naso-pharyngeal catarrh, the secretion is always more or less increased and altered in quality. It consists of mucus mingled with pus in various proportions, and has a yellowish or yellowish-green colour. It often forms tenacious masses, which appear behind the uvula, or dry up into dark yellowish or brown crusts, which adhere somewhat firmly to the posterior wall. In the nares, the dried secretion may either coat the surface of the mucous membrane or may form plugs, completely obstructing the passages, and exciting sensations similar to those caused by foreign bodies. Flakes of dried secretion accumulate in the nostrils; efforts at their removal not infrequently cause erosions and ulcers. Earthy concretions, "rhinoliths," are sometimes formed. On examination under the microscope, the most prominent changes are seen to be as follows: dilatation of capillary vessels, enlargement of the glands, infiltration of the tissue with lymphoid cells and consequent increase in bulk, and suppuration of the follicles. These appearances are often very marked near the pharyngeal orifices of the tubes.

Subjective Symptoms.—Many of the symptoms of naso-pharyngeal catarrh are due to the impediment to respiration; the patient complains that the nose is stopped up, and that he has to keep his mouth constantly open. As a result of this attitude, the expression after a time is liable to become changed; the patient acquires a dull, stupid look. Pain or a feeling of heaviness in the forehead and temples is often troublesome, and may be so severe as to incapacitate the sufferer for mental occupation. The voice is altered, and the senses of smell and taste are more or less blunted, and sometimes quite abolished. The patients frequently cough and hawk, in order to get rid of the tenacious secretion, and to lessen the feeling of dryness, irritation, and discomfort at the back of the throat. After a few hours' sleep, the dryness of the tongue and pharynx is apt to be very annoying.

There is often temporary deafness, from obstruction of one or both Eustachian tubes, and increased secretion in the external meatus.

In addition to the above-mentioned symptoms, there are certain nervous complaints which sometimes appear to be more or less closely connected with chronic affections of the nose. The phenomena are of reflex origin, and those which are most important take the form of paroxysms of asthma and spasmodic cough, migraine, vertigo, and facial neuralgia. It is supposed by some authorities that turgescence of the inferior turbinated body often plays an important part in the causation of these disorders; but other forms of intra-nasal disease are credited with a similar power of originating nervous symptoms.

Course and Changes Produced. — Chronic naso-pharyngeal catarrh may continue for indefinite periods, and is liable to produce marked changes in the mucous membrane. In one class of cases hypertrophy is the prevailing feature, and is accompanied by polypoid outgrowths (see page 271). In children, proliferation of the adenoid tissue, with serious consequences in the Eustachian tubes and tympana, is a common result. In another class of cases, the mucous membrane becomes atrophied, the nasal cavities are enlarged and contain accumulations of crusts which give rise to an offensive odour. Zaufal states that he has met with affections of the ear in about 80 per cent. of all cases of ozæna.* Patients with atrophic rhinitis are apt to grow more and more deaf as age advances. This process of atrophy sometimes follows the opposite condition, in which swelling and inflammatory thickening of the mucous membrane have been prominent symptoms. Ulceration is another consequence of naso-pharyngeal catarrh, and is often seen in syphilitic cases. It may be confined to the mucous membrane, or extend to the periosteum and the bones, producing more or less severe caries and necrosis. These processes are always accompanied by fœtid discharges from the nose, and often cause extensive destruction of the soft parts.

The connection between chronic naso-pharyngeal catarrh and aural disease may be thus described. The swelling of the mucous membrane is liable to extend to the pharyngeal openings of the tubes, which may also be occluded by masses of secretion; the catarrhal process may extend to the middle ear, and cause deafness, subjective auditory symptoms, and pain. In cases of ozæna, the aural affection is due to the closure or irritation of the pharyngeal openings of the tubes by the rhinitic discharges. Both sides are generally affected, for unilateral disease in the nose is extremely rare. In addition to these causes, the tympanum may be indirectly affected by loss of power of the muscular apparatus of the tube; and when a catarrhal condition is superadded, the difference must be very considerable, inasmuch as there is not only loss of power, but greater difficulty to be overcome. Atrophy of the muscles would appear to result from long-continued catarrh.

---

* *Archives of Otology*, 1894, p. 271; *Chronic Rhinitis Atrophica and Affections of the Ears*, Dr. J. Morf.

Treatment.—In dealing with chronic naso-pharyngeal catarrh, there are at least three objects to be attained: 1, removal of the secretion; 2, restoration of the mucous membrane to a normal condition; 3, stimulation of the muscular apparatus of the tubes. But before local measures are employed, it is necessary to ascertain whether there be any constitutional dyscrasia requiring attention. Syphilis, tuberculosis, and anæmic conditions must be dealt with by appropriate general remedies, without which local treatment will prove unavailing. Dyspepsia and constipation must also not be overlooked.

Removal of Secretion is best effected by thoroughly washing out the nares with an alkaline solution, to which an antiseptic may be at times added with advantage. It is often well to begin with a weak solution (3—10 grains to the ounce) of chloride of sodium, to which may be added the same quantity of bicarbonate of soda and borax, and two or three times the quantity of powdered white sugar. The last ingredient, by increasing the specific gravity of the solution, makes it less irritating, and at the same time causes it to be more pleasant to the taste. Chlorate and bicarbonate of potash may be used in the same proportion as chloride of sodium. In some cases of chronic catarrh, menthol is of service after the secretion has been removed by an alkaline lotion. The following formula is suitable for its application in the form of a spray:—

℞. Menthol gr. 5—15, Ol. Adepsin. Alb. ad ℥j. ft. sol.

Urbantschitsch recommends equal parts of milk and warm water to be used as an injection. Astringents are not well borne by the nasal mucous membrane, and when used should be very weak. According to Wendt, quoted by Politzer, solutions of alum are to be avoided, inasmuch as permanent loss of smell has been noticed after their use. As antiseptics, the sulpho-carbolate of zinc (gr. ½—2 to ℥j.), salicylic acid (gr. ½ to ℥j.), and boric acid (gr. v.—xv. to ℥j.), are suitable remedies, and as a stimulating application chloride of ammonium (gr. iij.—v. to ℥j.) may be employed. When the secretions are very fœtid, stronger antiseptic solutions, such as carbolic acid, ½—2 grains to the ounce or Liq. Potass. Permangan. (♏v.—xv. to ℥j.) may be used.

A large number of medicinal substances are recommended for improving the condition of the mucous membrane. With regard to them all it must be said that their efficacy varies much in different cases, and that a remedy which has acted very beneficially in one case may prove useless in another. Hence the necessity of being provided with several applications which can be tried in succession as required. The remedies in question may be used in several ways; thus, to begin with, they may be applied either in solution, or in the dry state as fine powders, or as ointments.

Solutions are best applied to the nose and naso-pharynx by means of a spray-producer, and failing that, by sniffing them through the nostrils from the hand or a small vessel made to fit the opening. The author never recommends the employment of a nasal douche, because its use is liable to be followed by acute inflammation of the middle ear caused by some of the lotion having passed along the Eustachian tube; or by severe and persistent headache, consequent on some of the fluid having forced its way into the frontal sinuses. Roosa's[*] experience is by no means unique, and yet the dangers attending the employment of this instrument appear to be comparatively unknown or disregarded. If a spray-producer were insufficient to clear inspissated mucus from the nostrils or naso-pharynx, there would be grounds for resorting to another method; but the author has always found that the instrument shown in Fig. 78 accomplished all it was intended to do. At his suggestion, Messrs. Mayer & Meltzer made this spray-producer with only one ball, which, in his opinion, is more serviceable than a similar apparatus fitted with two balls. When the latter is employed, the spray cannot be readily checked if the patient coughs, or, for any reason, wishes the application of the lotion to be quickly stopped; whereas with the former, the strength and duration of each jet of spray can be accurately regulated by the force used to compress the single ball.

---

[*] Dr. Roosa (*Diseases of the Ear*, p. 389) gives a list of sixteen cases in which injury to the ear resulted from the use of the nasal douche.

Although the employment of the nasal douche cannot be recommended, it may be well to refer to it, and to repeat the precautions considered necessary by its advocates.

The Nasal Douche was invented by Weber; it consists of a ar, capable of holding a pint of fluid, and of a piece of india-rubber tubing fitted at one end with an olive-shaped nose-piece. The tube acts as a siphon, and the vessel must therefore be placed on a higher level than the patient's head. When the tube is exhausted of air, a continuous flow takes place; the nose-piece is placed in one nostril, and when the fluid touches the upper surface of the soft palate, the latter rises and closes the passage into the throat; the fluid passes round the septum and escapes by the other nostril, thus washing out the naso-pharynx, and removing mucus and crusts. The patient should be directed to breathe quietly through the mouth while the douche is in action.

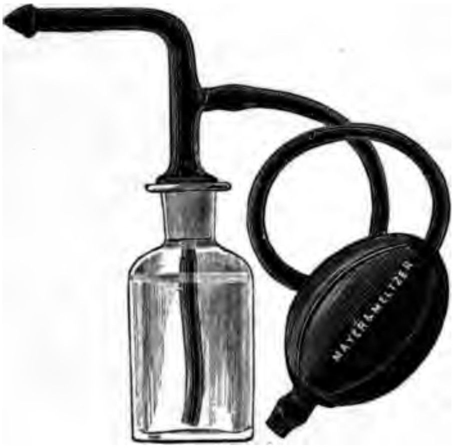


FIG. 78.

SINGLE BALL SPRAY-PRODUCER.

According to Politzer, the following precautions are necessary in using the douche. First, the vessel containing the fluid must not be too far above the head, and the flow should be occasionally interrupted by pinching the tube. Secondly, the head should be kept erect, directed neither forwards nor backwards; the patient must breathe through the mouth, and it will aid the closure of the throat if he keeps pronouncing the vowel sound "ah." Thirdly, if one nasal cavity be narrower than the other, the stream must be directed into it. Fourthly, tepid, non-irritating solutions of weak strength should always be used. Fifthly, if on any occasion fluid has passed into the middle ear, the douche must be laid aside; and in any given case, before allowing a patient to use it himself, it is requisite that he should be fully conversant with the necessary manipulations, and with these precautions.

The solutions most often used in this manner are as follows:—Solutions of boric acid or of common salt, 5—15 grains to the ounce. Politzer especially recommends a 10 per cent. solution of acetate of alumina, which he states has proved useful in several cases in which other remedies failed. Störk recommends a solution containing a tea-spoonful of a mixture of the following salts in a litre of water—the salicylate, bicarbonate, and chlorate of sodium, of each, twenty parts.

The Syringe affords a somewhat safer means than the douche of applying solutions which may be required to be injected into the anterior nares, or into the naso-pharynx. For the former purpose an olivary nose-piece is required, and the syringe should contain not more than two ounces of fluid; it should be held horizontally, and the fluid should be directed straight backwards. When it is wished to wash out the naso-pharynx, recourse may be had to a syringe furnished with a long tubular nozzle, with a curved extremity, so that when passed through the mouth, the point can be turned upwards behind the soft palate; but an ordinary syringe used through the anterior nares is generally sufficient to remove all secretion, and, moreover, causes the patient less discomfort. When the post-nasal syringe is used the head should be directed forwards, so that the fluid may escape through the nostrils. Only a slight amount of force must be used, as there is some danger of driving the solution into the tympanum.

When it seems desirable to apply a solution to the general surface of the mucous membrane of the nose and naso-pharynx, a **boat-shaped glass vessel** may be used, by means of which two table-spoonfuls of fluid can be poured into the nostrils when the head is inclined backwards. In order to prevent the solution from escaping into the lower part of the throat, the patient should breathe quickly through the mouth while it is being poured in; when the fluid is felt in the pharynx, the head must be quickly bent forwards, so that escape may take place through both nostrils; for the fluid, in consequence of the shutting-off of the lower part of the pharynx, will have passed into the other half of the nose. To ensure the action of the remedy upon the mucous membrane, and to prevent the passage into the tympanum of any that may remain, the patient should be prohibited from blowing his nose until a quarter of an hour has elapsed. When any of these methods is practised, the injected fluid will reach the pharyngeal orifice of the tube, and is liable by attraction to pass into the tube itself, and thus act indirectly upon the tympanum.

Inhalation is another method of applying remedies to the mucous membrane of the nose and naso-pharynx, and an ordinary inhaler with an india-rubber nose-piece fitted on the mouth-piece will answer the purpose. Steam from hot water relieves the feeling of dryness and tightness which sometimes accompanies chronic catarrhs when secretion is very scanty, and it also softens layers and plugs of inspissated secretion. The vapour of *chloride of ammonium* in the nascent state has a good effect as a stimulant when the mucous membrane is relaxed and swollen. There are many different kinds of inhalers for generating these fumes—Basdon's and Godfrey's may be mentioned as acting efficiently. Other remedies are (1) Creasote, used as follows:—℞. Creasoti ♏80, Magnesiæ Carbonatis Levis ʒss., Aquam ad ℥j.; a tea-spoonful to be added to a pint of water at 140° for each inhalation. (2) Tinctur. Benzoin. Comp., a tea-spoonful to be used in a similar manner, and its stimulating properties may be increased by adding ♏v. Ol. Pini Sylvestris to each ʒj. As a more stimulating remedy, the following may be employed:—℞. Ol. Pini Sylvestris ♏40, Magnes. Carbonat. Levis. gr. 20; Spirit. Camphoræ ♏40, Aquam ad ℥j. A tea-spoonful to be added to a pint of water at 140° for each inhalation.

Application of Ointments.—Remedies can also be applied to the nasal mucous membrane in the form of ointment, and it is sometimes desirable to apply them in this manner after the use of the douche. The boric acid ointment is antiseptic and sedative in its action, and relieves irritation in cases of subacute and chronic catarrh; and menthol ʒss.—ʒj., mixed with oil of sweet almonds ℥j., is also sometimes of use. When excessive secretion is a prominent symptom, belladonna ointment is useful, and a more efficacious preparation is composed as follows:—℞. Liq. Atropinæ Sulphat. ʒss.—ʒj.; Vaselini ℥j. When dryness of the membrane is a marked symptom, the following will relieve discomfort:—℞. Eucalypti Olei ʒj., Vaselini ℥j. An ointment containing five grains of hydrochlorate of cocaine to the ounce will prove serviceable when the mucous membrane is hyperæmic, relaxed, and swollen. In some cases in which abrasions or ulcerations exist, hazeline cream is a useful application, or an ointment such as the following:—℞. Zinci Oxidi ʒss., Ung. Hydrarg. Nit. ʒss., Vaselin. ad ℥j.

If the catarrhal condition of the nose and pharynx prove very obstinate, and unaffected by the remedies just described, the application of a solution of nitrate of silver (ʒss.—ʒj. ad ℥j.) may be applied to the diseased portions by means of a camel-hair brush, or on a piece of absorbent wool.

The application of a strong solution of nitrate of silver causes a severe burning pain and increased secretion. If the action be very severe, it should be neutralised by injecting tepid water, or a weak solution of common salt. The application should be made twice or three times a week, and may have to be repeated for two or three weeks. If it be desired to apply the solution to the naso-pharynx, a brush is required, fixed to a suitably bent handle. This can be passed behind the soft palate, and applied to the roof and walls of the naso-pharynx. In cases of atrophic rhinitis, a feeling of dryness at the back of the throat is often very troublesome. It may be relieved by the application of a solution of iodine gr. vj., iodide of potassium gr. xij., in glycerine ℥ss.

Insufflation is another method of applying remedies to the nose and naso-pharynx. Very fine powders are required, and only small quantities should be used at one time. As but little good can be expected from the patient's attempts to "snuff up" powders, a proper instrument is always necessary. Kabierskie's insufflator (Fig. 79) is a good apparatus. It works best when the powder is below the india-rubber valve in the centre of the bottle. Besides Kabierskie's there are various other forms of insufflators, by means of which the powders can be introduced into the nose or throat; but with these instruments the powder is not so evenly or so finely distributed as with Kabierskie's insufflator. A piece of india-rubber tubing, furnished with an elastic ball at one end, and a vulcanite tube at the other, is suitable for most cases. The powder is introduced through an opening in the wall of the tube, which is then closed with a slide or the finger. Tubes of different curvatures may be required for different cases; but an instrument with an arm about half an inch long, bent at a right angle with the stem, will be found suitable in most cases for applying powders directly to the naso-pharynx.

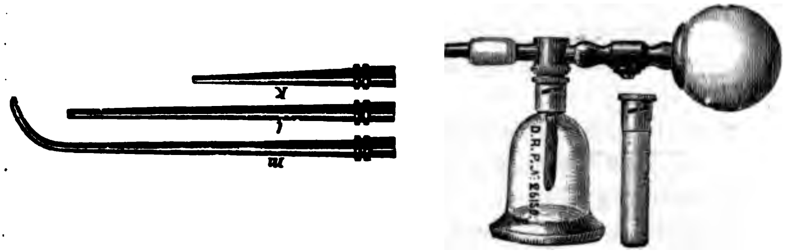


FIG. 79.

KABIERSKIE'S INSUFFLATOR.

Fitted for use with small hand tube as shown in woodcut, as well as with flat-based bottle.

The insufflation may be made through the nostrils, whether the nose or the naso-pharynx be the seat of disease, and this method is especially preferable when both regions are affected; but in some cases, when the naso-pharynx alone is diseased, it is best to apply the remedy directly to that region through the mouth. Boric acid is best mixed with oxychloride of bismuth or sugar of milk. Grains 20 to 30 of boric acid to 2 drachms of the latter make a suitable mixture. Menthol may be used as follows:—Menthol, grain 1, oxychloride of bismuth, grains 24, powdered starch, grains 25. Iodol may be mixed with half its weight or more of starch, or added to the mixture of boric acid and bismuth. Hydrochlorate of morphia one-sixteenth to one-eighth of a grain mixed with about a grain of starch, is useful for allaying pain. For some syphilitic cases sublimated calomel is serviceable when blown into the nostrils by means of a suitable appliance (Fig. 80) with lamp attached.

Nasal Bougies.—There is yet another way of applying remedies to the nasal mucous membrane, viz., the introduction of bougies, having a gelato-glycerine basis, with which the drug is incorporated. Iodoform (gr. $\frac{1}{6}$—$\frac{1}{2}$), carbolic acid (gr. $\frac{1}{2}$), hydrochlorate of cocaine (gr. $\frac{1}{6}$), sulphate of copper (gr. $\frac{1}{10}$), and sulphate of zinc (gr. $\frac{1}{10}$) can be applied in this manner. As the basis gradually liquefies, the action of the remedy is maintained for some time. The disadvantage of this mode of treatment is that the bougie, when partially melted, is liable to slip down the patient's throat or out of the anterior opening of the nostril.

Cauterisation.—When the mucous membrane is much swollen, and ordinary treatment has failed to produce the desired effect, the careful application of the galvano-cautery will sometimes prove very efficacious. The extremity of the electrode should be adapted to the part to which it is to be applied. Sometimes it is desirable to produce a somewhat large superficial slough, but more often linear cauterisation will produce the best effect. The use of the cautery should be preceded by the application of a solution of eucaine A (20 per cent.), or of cocaine (10—20 per cent.), and as some individuals are easily affected by the latter drug, and a feeling of faintness in consequence quickly supervenes, no more than is necessary should be used. In some cases in which a nostril is narrow, a better view is obtained with cocaine than with eucaine. It is sometimes advisable, when both nostrils require to be cauterised, to anæsthetise one, and then determine whether the other shall be treated, at that interview or on another occasion. When

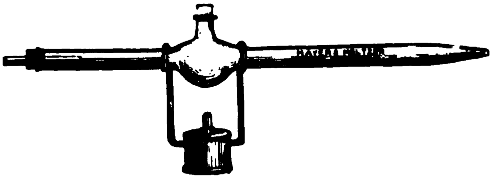


FIG. 80.

FUMIGATOR, WITH SPIRIT LAMP.

the part to be cauterised is within view, it is best anæsthetised by placing against it a piece of absorbent wool twisted on to the end of a probe and wetted with the solution. If a spray-producer is used, one made of vulcanite should be preferred (Fig. 53, page 132), as this material is not acted upon by the drug. Before applying cocaine, the part to be cauterised must be carefully determined, because the swelling of the tissues will disappear as soon as the drug takes effect. Finding that Schech's cautery handle was frequently getting out of order, the writer had a handle made (Fig. 81), with the connections on the surface, and the movable pole arranged as a long spring, so that it could be easily depressed.

Before using the cautery, the anterior orifice of the nostril should be dilated with a speculum having solid blades, in order to press aside the hairs usually found in that region in adults. Care should be taken not to carry the cautery so far back as to touch the Eustachian orifice. It is important to bear in mind that, as long as the point of the cautery is in contact with moist tissue, no light is emitted from it. Should light become visible, the point is evidently in contact with the bony wall, and the cauterisation must be immediately discontinued. Should it be necessary to introduce the cautery into the naso-pharynx, the soft palate should be previously painted with a solution of cocaine, and, when anæsthetised, held forward by means of a soft palate tractor. The danger of inflammation extending along the Eustachian tube and producing suppuration in the middle ear must not be forgotten. When cauterising a nostril, care is necessary to prevent two opposite parts of the cavity being

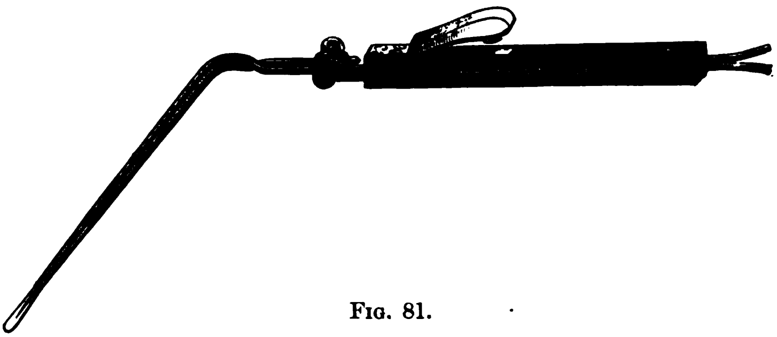


FIG. 81.

THE AUTHOR'S ELECTRODE HANDLE.

touched with the electrode, because if both surfaces have been burned, they are liable to unite when they come in apposition, as a result of the swelling of the tissues which always follows the operation. The use of a plug for the purpose of keeping the sides apart after cauterisation is not advisable, as it is liable to rub off the epithelium and to create a raw surface which may result in an adhesion. It is usually desirable to wait about a fortnight before again applying the cautery, so as to allow all inflammatory swelling to subside and the surface to heal, but sometimes a longer interval is required to enable the latter process to be thoroughly completed.

As substitutes for the galvano-cautery, various chemical agents are available for the destruction of hypertrophied portions of the mucous membrane, but the objection to their use is that their action cannot be precisely limited. The most efficacious of these are: chromic acid, glacial acetic acid, nitrate of silver, chloride of zinc (a concentrated solution), and nitrate of mercury. If a proper chromic acid carrier (Fig. 82) is not at hand, a silver probe, grooved near its apex, is a convenient instrument for applying this remedy, and also nitrate of silver.

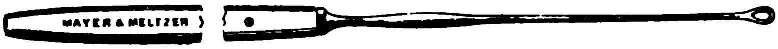


FIG. 82.

CHROMIC ACID CARRIER.

Whilst the application is being made, the nostril should be kept dilated by means of a speculum. A solution of cocaine or eucaine should be previously applied, and after the cauterisation (with chromic acid) has been effected, it is well to use the spray-apparatus with a strong solution of bicarbonate of soda. The fluid caustics, according to their nature, may be applied on a small glass or camel-hair brush, or on a strip of cane having one end slightly crushed, so as to be capable of taking up a small amount of fluid, provided the chromic acid carrier (Fig. 82) is unsuitable for the purpose. Before the application, any superfluous liquid should be removed with a piece of absorbent wool or blotting-paper. Various modifications of the instruments will be required when the naso-pharynx is especially affected.

When **ozæna** exists, the free use of an alkaline lotion and the application of antiseptic remedies are necessary parts of the treatment. By means of the former, masses of inspissated secretion and crusts are removed, and deodorànts are required to destroy the fœtor. In many cases it is advisable for the crusts to be moved with a probe before the lotion is used, and patients generally soon learn to do this for themselves. Benefit may also be derived from the inhalation through the nostrils of iodised spray from a Siegle's apparatus, or of iodine vapour, a few drops of Tinct. Iodi being placed in a suitable inhaler filled with warm water.

Some authorities strongly recommend Gottstein's method of treating ozæna. This consists in the introduction into the nostrils of plugs of wadding, either dry or moistened with glycerine, and about two inches in length. These are allowed to remain in position for several hours, or even for an entire day. The wadding absorbs the secretion and prevents the formation of crusts, and the odour is more or less diminished. This plan is, of course, to be regarded as only a palliative measure. It may be advantageously combined with insufflations of powdered boric acid diluted with oxychloride of bismuth or of aristol. The plugs of wadding are changed twice or three times a day, and the remedies are blown into the nostrils before the wadding is replaced. The application of the electro-cautery is at times beneficial. The author has found in many cases that if the crusts are carefully removed, and the nostrils thoroughly sprayed two or three times a day with a carbolate of soda solution, many months may elapse without any odour being detected.

For syphilitic ozæna special treatment will, of course, be required, and the calomel fumigator (Fig. 80) directed to the nasal cavities will be the most suitable method. The action of the mercury must be carefully watched, especially in cases in which there are signs of osseous lesions. Under such circumstances, iron and cod-liver oil will probably be indicated.

Hypertrophy of the Posterior Extremity of the Inferior Turbinated Body.—The posterior extremity of the inferior turbinated body is sometimes considerably hypertrophied. There is no distinct pedunculated tumour, and the growth appears to be due to hyperplasia of connective tissue, infiltration with lymphoid cells, and formation of new vessels. It more or less resembles a raspberry in appearance, and may attain a considerable size, filling up the choana and reaching the pharyngeal orifice of the Eustachian tube (Fig. 83).

This enlargement is best removed by means of a wire snare, which can be worked with one hand; and as the region is sensitive, an anæsthetic is desirable. Nitrous oxide gas with the addition of a little ether is the most suitable, but cocaine may be employed. The drawback to the use of the latter is the contraction it produces of the tissues with which it is brought in contact. The posterior surface of the soft palate should be anæsthetised as well as the nostril. For these cases the author uses his modification of Sir Morell Mackenzie's nasal snare (see Fig. 84, p. 286). The operation should be performed as follows:—A wire loop placed vertically should be passed through the nostril, and the forefinger of the left hand then introduced into the naso-pharynx. The loop should then be pressed outwards as far as possible by this finger whilst it is being tightened, and the hypertrophied tissue will be felt to become tense if it has been caught in the snare. When the extremity of each inferior turbinated body is enlarged, both should be removed at the same operation. It is desirable to have several snares at hand, so that time may not be lost in remaking a loop if the hypertrophied tissue is not at once seized. Occasionally free hæmorrhage follows removal, but it usually stops in the course of a few minutes.

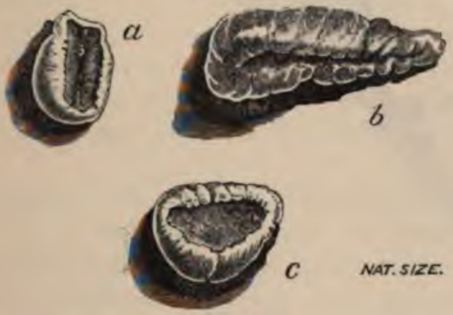


FIG. 83.

SWOLLEN POSTERIOR EXTREMITIES OF INFERIOR TURBINATED BODIES.

a and *c* are each drawn from the swollen posterior extremity of an inferior turbinated body after removal with a snare in the manner described. In the case of *b* the snare has removed not only the end but also a portion of the inner surface of the turbinated body in consequence of the tissues being very much hypertrophied.

Treatment of Nasal Polypus.—When a polypus exists in conjunction with catarrh or chronic suppurative inflammation of the middle ear, it is especially desirable to remove it without delay. In all cases the part to be operated on should be anæsthetised either by the application of eucaine (10—20 per cent. solution) on absorbent wool twisted around the end of a probe, or by cocaine (5—10 per cent. solution) applied either by means of a spray-producer or on absorbent wool; the latter method is convenient when the polypus is small or the part to be anæsthetised can be easily reached. In some cases a 15 or 20 per cent. solution of cocaine is preferable. As soon as the parts are insensible, a good light should be reflected into the nostril, and a loop of wire sufficiently large to pass easily over the polypus to be removed should be introduced by means of a snare (Fig. 84), and worked gently backwards and forwards, whilst it is being raised to the attachment of the pedicle to the part from which it is growing. The loop should then be carefully contracted until it closely embraces the pedicle at its origin, when it should be further tightened until the pedicle is severed. When more than one polypus exists, each must be removed separately as above described. It often happens, after a nostril has apparently been cleared, that in the course of a day or so other polypi make their

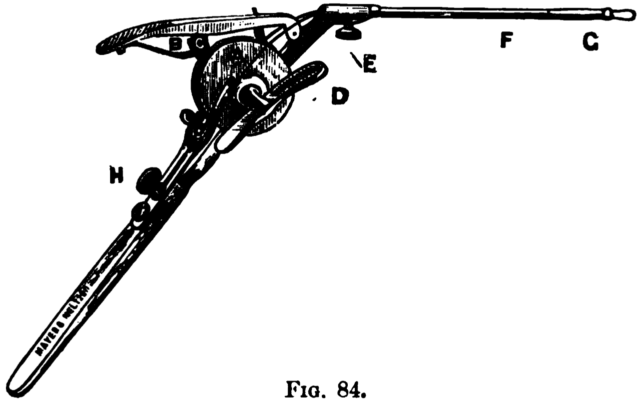


FIG. 84.

THE AUTHOR'S MODIFICATION (WITH LATEST IMPROVEMENTS) OF SIR MORELL MACKENZIE'S NASAL SNARE.

The modification consists of the following additions :—The flange A, to prevent the wire getting twisted round the axle. The shoulder B to the pawl C, to prevent the latter being forced off the ratchet. The cross-bar D attached directly to the axle to give increased cutting power when required. The screw E to fix the revolving barrel F in the necessary position. The adoption of the movable end G fitted at its extremity with a pin which separates the two sides of the loop of wire. When the end G is drawn off the barrel F the wire is unwound from the axle and the loop re-formed, thus saving the time spent in fitting another wire. H, a guard to prevent the wire getting off the axle.

appearance. These probably have been wedged by the polypus which has been removed into a position in which they could not be seen, and on its pressure being taken away, they have gravitated into the region which it occupied. When a polypus is attached far back in the nostril, it is sometimes necessary to insert the left forefinger into the naso-pharynx and push the polypus through the loop of the snare. During this manipulation, the finger should be protected with the india-rubber guard (Fig. 43, page 114).

After a polypus has been removed, its base should be anæsthetised, and then destroyed with the electro-cautery to prevent recurrence. As a rule, the bleeding caused by the operation obscures more or less a view of the parts, and therefore the cauterisation is best done after an interval of a few days has elapsed, to allow the subsidence of any swelling of the tissues which may have resulted from the irritation of the operation.

Small mucous polypi not infrequently disappear under the steady use of a saturated solution of chromic acid; finely powdered tannin applied daily for a few weeks by an insufflator is sometimes employed for the same purpose. Both these methods, however, are less certain and slower in their action than the use of the electro-cautery.

It is to be regretted that some surgeons still systematically adhere to the primitive method of tearing polypi from the nostrils with forceps. In olden times, this painful procedure was necessary because the frontal mirror was unknown, and consequently the treatment of intra-nasal affections by the aid of reflected light could not be practised. At the present day, however, a surgeon's neglect to make himself efficient with this instrument is not an excuse for a method of operation which not only causes unnecessary pain, but which, in many cases, is less efficacious than the removal of the polypus by the snare, and subsequent destruction of its attachment with the electro-cautery. Still more to be deprecated is the performance of an operation which reflects the cartilaginous portion of the nostril, in order to obtain a better view of the growth and facilitate the removal of a polypus with forceps because it has recurred after a portion of it had been evulsed with that instrument. In such a case it might have been foretold before the first operation was performed, that recurrence would take place unless only one polypus existed attached by a narrow pedicle, and the operator happened to seize it near its origin.

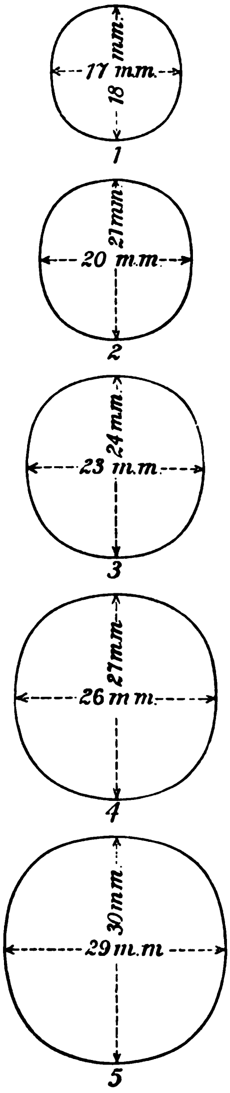


FIG. 85.

THE DIMENSIONS OF THE AUTHOR'S SET OF TONSILLOTOMES.

Not only does the attempted removal of a polypus with forceps cause unnecessary pain, but the result is far less certain than that obtained by the use of a snare and subsequent destruction of the attachment of the growth with the electro-cautery. Furthermore, by the former method healthy tissues and structures are frequently not only injured but even torn away.

Treatment of Enlarged Tonsils.—It has been previously mentioned that enlargement of the tonsils and granular pharyngitis are frequently found in patients who are suffering from middle-ear catarrh; and although those affections cannot be regarded as direct causes of this complaint, their treatment must not be neglected, as the presence of enlarged tonsils tends to keep up the conditions which immediately produce it, and granular pharyngitis, if it does not always have this effect, is nevertheless attended by changes which may produce this result. For the removal of tonsils, Morell Mackenzie's modification of Physick's tonsillotome (Fig. 86) is the most suitable instrument. It is usually sold in a set of three sizes, but as it is important that the tonsil, to ensure its complete removal, should be closely embraced by the ring, the author uses a set of five sizes, the diameters of which are shown in Fig. 85. When operating, the surgeon should always hold the tonsillotome in his right hand, and therefore have a pair of each size, because it is better for the blade to be held towards the mesial line, so that the flat and immovable portion of the instrument may be in contact with the pillars of the fauces. Fig. 86 represents a tonsillotome for the removal of the right tonsil, and the dotted handle as attached to the instrument represents a tonsillotome for the left tonsil, but placed upside down. The fork which is attached to some forms of tonsillotome is unnecessary, and, moreover, is liable to cause injury to the soft palate or other parts, if the patient resists the introduction of the instrument.

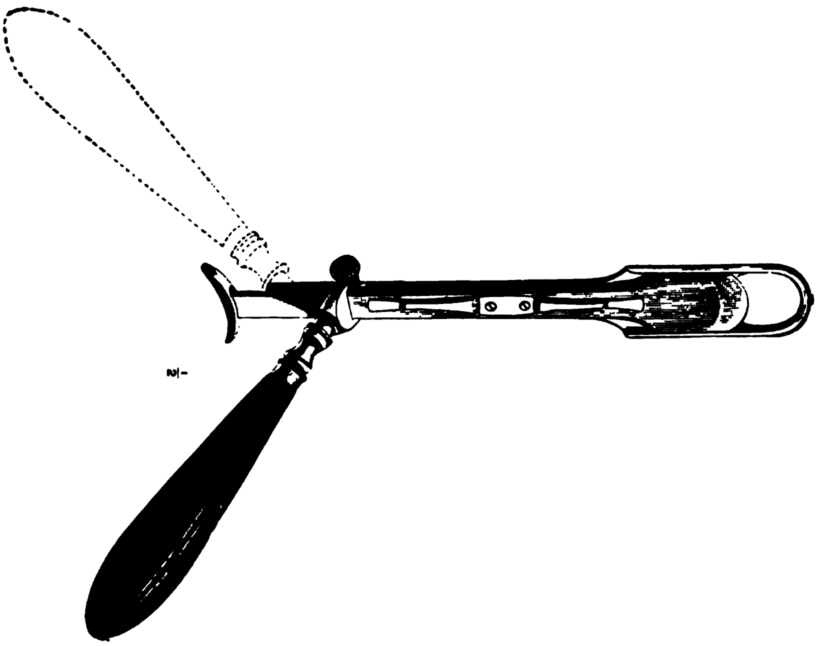


Fig. 86.

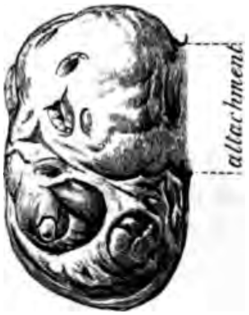
Morell Mackenzie's Modification of Physick's Tonsillotome.

It is inexpedient to remove tonsils whilst they are inflamed, and after an attack of tonsillitis, it is advisable to wait until they have resumed their normal condition before the operation is undertaken; in some cases it is desirable for an astringent to be applied daily for a week or ten days before they are excised. In cases of syphilis, it is best to postpone the removal of tonsils until the mucous patches have disappeared from the mouth and fauces, unless there are circumstances which require the tonsils to be excised without delay. In the latter case, too much care cannot be exercised in thoroughly disinfecting the instruments after use.

A general anæsthetic should not be administered for this operation as a matter of routine, because it is not only unnecessary in many cases, and therefore entails needless complications, but also introduces a possible source of danger. When properly performed, the removal of tonsils is almost painless, provided the guillotines are in good condition. In the case of adults and some children, the fauces may be sprayed with a 2—5 per cent. solution of cocaine a few minutes before the operation is begun, but in young and nervous children this drug is best dispensed with, as its application and the peculiar sensation it produces cause as much alarm as the operation itself. In dealing with such cases, a general anæsthetic may be administered with advantage, but the patient should not be placed deeply under the influence of the drug. The gag should be placed on the opposite side of the mouth to that from which the tonsil is to be excised, otherwise the handle of the tonsillotome cannot be carried outwards sufficiently to enable the whole of the anterior part of the tonsil to be removed. When both tonsils have to be excised it is well to be provided with two gags, so that the second can be slipped into position before the first is taken away. In all cases in which the operation is performed whilst the patient is unconscious, or when a good view of the fauces cannot be obtained, the forefinger of the left hand should be placed against the soft palate so as to lift the uvula out of the way, otherwise its tip may be cut off by the guillotine.

Should it happen that a tonsil, when excised, falls into the pharynx whilst the patient is under the influence of an anæsthetic, he should be allowed to come to sufficiently to cough it up, because while the tonsil remains in the pharynx there is risk of its getting into the air-passages.

For the operation, the patient should be seated either with his back to the window, or by the side of a powerful lamp, and it is desirable to protect the front of his clothes by pinning a towel round his neck. The surgeon will do well to adopt a similar precaution, especially in the case of a child. One assistant, standing behind the patient, should support his head by allowing it to rest against his chest, whilst he steadies it laterally by placing a hand on each side, and he should put the second finger over the region of the tonsil in readiness to make pressure with it whilst the tonsil is being removed. In the case of a child, another assistant should sit by the side of the patient, and hold both his hands, to prevent him from dragging the tonsillotome from his mouth during the operation. The surgeon, wearing a frontal mirror to reflect the light into the fauces, should seat himself in front of the patient, and draw his chair against the patient's legs in order to prevent him kicking. As soon as the tonsil to be excised has been well illuminated, the tonsillotome should be slipped over it, care being taken not to include the tip of the uvula, and to carry the stem of the instrument as far as possible from the mesial line (see Fig. 88), before the blade is driven home by the thumb of the hand which is holding the tonsillotome. The object of thus carrying the stem of the instrument away from the mesial line is to ensure the removal of the whole of the anterior surface of the tonsil, the external portion of which is often left uncut when this procedure is omitted, on account of the outer portions of this surface of the tonsil lying on a plane external to the corresponding portion of the posterior surface. Fig. 87 shows an enlarged tonsil removed from a man aged twenty-one years, and well illustrates the condition usually present, viz., that only a portion of the external surface of an enlarged tonsil is attached to the fauces.



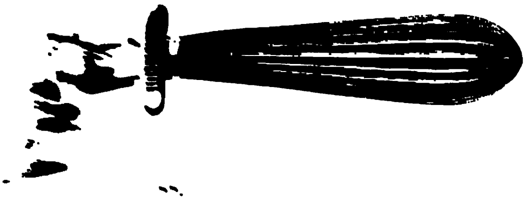
nat. size.

FIG. 87.

THE LEFT TONSIL REMOVED FROM A MAN AGED 21 YEARS.

It has been previously mentioned that in order to ensure the complete removal of the projecting portion of a tonsil, it should be closely embraced by the rings of the tonsillotome. This

much sil, unless its attachment
instru Fig. 88 shows diagram-
A llotome should be placed
operat the tonsil. 2. The tonsil-
unnec mes in contact with the
plicati tonsillotome in position
prope 2 and 3 shows the course
provi tome between the second
adult of the instrument at the
per al application of a tonsillo-
begun sions shown in the diagram.
pens er border of the instrument
prod ndent portion of the tonsil
with
adva blade of the tonsillotome
the
oppo
be
carri
part
be
the
away
the
cam



OF APPLYING A TONSILLOTOME.

plac tonsil is still held to the fauces
th s membrane. When this occurs,
pressed against the further side
pl ged off by the index finger of the
he e tonsillotome. It is a mistake.
be w the blade and remove the ton-
of ase the tonsil is then left hanging.
scissors—a procedure often difficult

hi
it pen his mouth, no attempt should
tow part by twisting the tonsillotome, as
sit oken or loosened by this method:
ass e held horizontally, and slipped as
by e pharynx. This causes the patient
lat opens his mouth widely; the tonsil-

lotome should then be quickly slipped into position, and the operation performed.

In most cases merely rinsing the mouth with cold water is sufficient to check any bleeding which may follow the operation; but sometimes other measures, such as cold or the application of astringents, are required. Ice held in the mouth is often all that is necessary, and it is preferable to an astringent, as it interferes less with the healing processes. When, however, it is not sufficient to stop the bleeding, astringents should be used. The following gargle of tannic and gallic acids in the Throat Hospital Pharmacopœia is very useful in such cases:—

℞ Tannic acid, ʒvj.
Gallic acid, ʒij.
Water, ℥j.

Rub the acids to a fine powder, and mix with the water.

Directions.—The patient should be directed to sip the mixture slowly, or hold it passively in the mouth till the hæmorrhage is stopped.

When the bleeding is coming from a small artery, the vessel should be squeezed with a pair of torsion forceps. It occasionally happens that severe hæmorrhage follows the operation, and the common carotid artery has been tied, in order to arrest it, in more than one instance. The author's experience of these cases during the last twenty-five years leads him strongly to recommend the following measure, as obviating the necessity for an operation, provided that a large vessel has not been wounded.

He has successfully employed it after cold, pressure, and astringents, including iron, failed to check the bleeding; and he has never been disappointed, even in severe cases.

To Arrest Severe Hæmorrhage, mix together tannic acid, 3 parts; gallic acid, 1 part; and add a few drops of water.

Then knead the powder until it is a *hard* mass, and from it take a piece sufficient to form a ball the size of a small marble. Place this on the forefinger of the hand corresponding to the side of the patient from which the hæmorrhage is occurring, and by this means introduce it into the patient's mouth, and rub it *firmly* against the bleeding surface, making counter pressure with the palm of the other hand, placed on the side of the head over the region of the tonsil.

Note.—It will be found, on continuing to knead the powder, that it requires less water than at first appeared necessary to make it into a mass, and it is important to bear this in mind, because unless only a few drops of water are added the mass will be too soft to be of use, as the saliva or blood quickly moistens it when introduced into the mouth.

As a general rule, after excision of the tonsils, the parts should be kept at rest; it is therefore not advisable to gargle the throat. When there is a tendency for the neighbouring tissues to become inflamed, ice may be sucked with advantage, and in some cases its use lessens the feeling of soreness. The marshmallow lozenges of the Throat Hospital Pharmacopœia are useful in the case of children, and for adults the bismuth and morphia pastilles of the same Pharmacopœia are often of service. In spite of the patient's sucking ice, œdema of the soft palate and uvula sometimes ensues, and the author has known acute suppurative inflammation of the middle ear to follow the excision of the tonsil on the same side, in the absence of any apparent cause for this severe inflammation following the operation. When œdema occurs, the application of ice should be continued, and considerable relief will be afforded, and the duration of the attack lessened, if the swollen tissues around the uvula be scarified. For this purpose the author uses the instrument shown in Fig. 89, made by Messrs. Mayer & Meltzer, to fit into his pocket case. Each of the ends A has a T-shaped piece (a and a') projecting from their

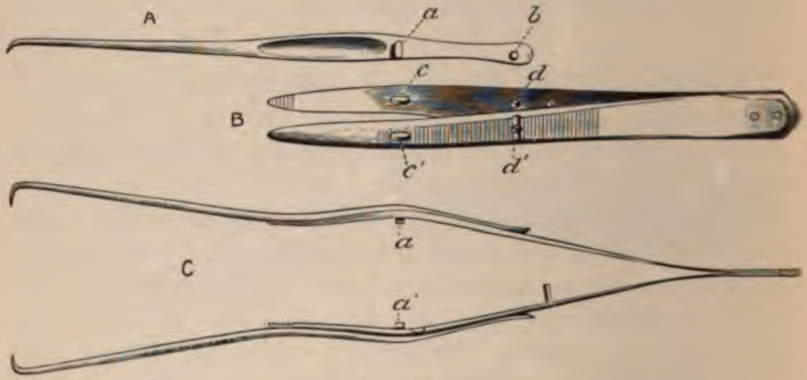


FIG. 89.

THE AUTHOR'S UVULA SCARIFIER.

inner surface, which pass through the apertures (*c* and *c′*) in the blades of an ordinary pair of dissecting forceps B. As will be seen in the figures, the top of the T in A and C is at a right angle to the blade of the instrument, which must therefore be placed at a right angle to the forceps in order to allow the T-piece to pass through the aperture *c*. On twisting the blade A to its position shown in C, the pin (*b*) slips into the hole (*d*), and holds the blade securely in position. The total length of the instrument, as shown at C, is eight inches. With this instrument the uvula is easily scarified, as it is pierced on each side simultaneously by the points. The previous application of a solution of cocaine makes the procedure painless. A good deal of pain in the fauces is sometimes experienced during the act of swallowing for a day or so after the tonsils have been removed, and in the case of delicate children it may be advisable to adopt some measure for its relief.

The following simple **Method for Relieving Odynphagia** deserves to be better known, as it is applicable to all cases, whether the cause be malignant disease, scarlet fever, diphtheria, phthisis, tonsillitis, or any other affection. It is performed as follows:—A person standing behind the patient, who should be seated on a chair or in bed, places the palm of each hand, with *the fingers pointed directly upwards*, over the ear on the corresponding side, and then makes firm pressure towards the mesial line. The greater the pressure the greater will be the relief from the pain during swallowing.

Granular Pharyngitis* is often found associated with catarrh of the middle ear, and when the side of the pharynx behind the posterior pillars is involved, it is especially prone to keep up the mischief in the corresponding ear. When the tissues become hypertrophied in this position, the patency of the Eustachian tube on the corresponding side is usually interfered with, and in many cases the patient is unable to inflate the tympanum by Valsalva's method. The irritation experienced is often referred to the inner end of the meatus, below its floor, and attempts are made to scratch the place with a finger or some instrument passed into the meatus.

Improper voice-production was formerly believed to be the primary cause of granular pharyngitis, but the author for many years has held a very different view. He attributes it to irritation of the gastro-intestinal or utero-vaginal mucous membrane, and considers that the discomfort which results from singing, reading aloud, or any prolonged or excessive use of the voice, is due to irritation of the granulations which have been brought already into existence by the more remote disorder. The large number of individuals who suffer from this affection, and yet do not use their voice in public, or to an excessive degree; and the prevalence of the disorder amongst females to an equal or even greater extent than amongst males, show that the old theory as regards the etiology of the affection is incorrect. The author considers dyspepsia in its various forms the most frequent cause of the disorder; and he has found that it may be kept up by an amount of gastro-intestinal irritation which is insufficient to cause the patient to be aware that he suffers from indigestion. Constipation and disorders of menstruation, especially those in which the periods are too frequent and profuse, are usually found associated with granular pharyngitis, and the affection is generally co-existent with profuse leucorrhea. Some of the worst instances met with by the author occurred in women who were suffering from uterine derangement, the hypertrophied tissue in these cases being most abundant behind the posterior pillars. Patients suffering from granular pharyngitis usually experience increased discomfort in damp weather, and frequently also during the prevalence of an easterly wind. In many instances the throat is more uncomfortable in the evening or at other times when the patient is feeling fatigued; it is also liable to be irritated by dust, as in a ball-room, or by vitiated air. In cases of chronic middle-ear catarrh, associated with granular pharyngitis, the increase in the symptoms during damp weather is doubtless partly consequent on the aggravated state of the granular pharyngitis which has resulted from the climatic condition.

---

* For further details see a paper by the Author, *Medical Press and Circular*, October 19, 1892, p. 391.

The **Treatment** of granular pharyngitis must be first directed to remove the source of irritation which has produced and is keeping up the affection, and until this result has been obtained local applications will not afford permanent benefit. To relieve the local irritation the pastilles of bismuth and morphia (Throat Hosp. Phar.) will be found serviceable, and borax with glycerine or syrup of Virginian prune are sometimes useful. Astringents, if weak, often give relief, but when too strong they are apt to irritate. The destruction of the granulations with the electric cautery should be postponed until the pharyngeal congestion has subsided, otherwise they are almost sure to recur, and it is obviously desirable not to destroy more mucous membrane than is necessary. When using the cautery, care should be taken to touch the granulations lightly, otherwise the deeper layer of fascia will be unnecessarily involved in the cicatrix. A 10—20 per cent. solution of cocaine should be applied to the granules which are to be touched with the cautery; and for this purpose the author prefers to use a piece of absorbent wool on a probe or a brush, rather than a spray-producer, because by the former methods less cocaine is swallowed, and therefore there is not so much liability to the unpleasant sensations produced by this drug. It must not be forgotten that pharyngeal congestion usually accompanies nasal obstruction, in consequence of the oral breathing which results, and when associated with ear disease, it is especially desirable to obtain a permanent free passage through each nostril.

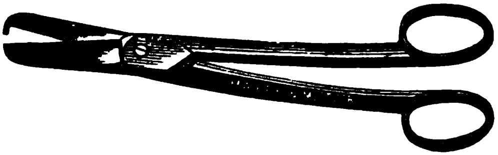


FIG. 90.

NUNN'S UVULA SCISSORS.

Congestion of the pharynx is sometimes partly the result of the irritation produced by an elongated uvula, and when this is the case the superfluous mucous membrane should be removed. This operation is best performed by seizing the tip of the redundant portion of mucous membrane with a long pair of mouse-toothed forceps after the part has been anæsthetised with cocaine, and removing it with suitable scissors (Fig. 90). The incision should be made to pass obliquely from side to side immediately below the end of the azygos uvulæ muscle, and to terminate about an eighth of an inch above that point. When the muscular tissue is hypertrophied, a portion of it must be taken away, as well as the end of the lax mucous membrane. If the operation is done as above described, the uvula retains its pointed shape, and when the parts have healed it is difficult to detect that any portion of it has been removed.

Morbid Growths of various kinds are found in the naso-pharynx, and may be divided into two principal classes, (*a*) innocent and (*b*) malignant. To the former class belong (1) fibromata, (2) enchondromata, (3) mucous polypi, springing from various parts of the posterior nares, and (4) adenoid growths. The polypoid degeneration of the inferior turbinated body previously mentioned (page 284) may also be again referred to as projecting into this region. Malignant growths (carcinoma and sarcoma) less frequently affect the naso-pharynx.

All these growths are liable to occlude the mouths of the Eustachian tubes and to cause more or less deafness. The fibrous growths spring from the periosteum of the walls of the naso-pharynx, and most frequently from the roof; the patients are usually males between 10 and 25 years of age. The growths rapidly increase in size, sometimes becoming as large as an ordinary apple; and they may in the course of time block up one or both Eustachian tubes. Hæmorrhage frequently occurs, and sometimes to such a degree as to produce decided anæmia. In the early stages, on examination with the finger, a firm, smooth growth can be felt, and its extent can be more or less easily traced. When ulceration occurs, a foul-smelling secretion escapes by the mouth and nose, and may pass downwards into the stomach. Enchondromata are very rarely found in the naso-pharynx. They may extend in various directions and attain a considerable size; but they are not accompanied by profuse hæmorrhage. Mucous polypi are frequently found in the naso-pharynx, but usually in connection with similar growths in the nostril. Their place of origin varies; sometimes they spring from the middle or inferior turbinate and extend backwards and downwards. In other cases they are attached to the lateral wall, between the pharyngeal orifice of the Eustachian tube and the extremity of the inferior turbinate. In a third class of cases, they are attached to the margin of the choanæ. Malignant growths are soft to the touch, rapidly increase in size, soon become ulcerated and extend to adjacent parts.

The **Treatment** of growths in the naso-pharynx, other than adenoid growths, requires only a brief description in this work. Fibrous growths, on account of their size and prolongations, and the adhesions they are apt to form, may present many difficulties to the operator. For the procedure necessary for their removal, a work on general surgery must be consulted. Mucous polypi can generally be removed through the nostrils by means of a wire snare, if the loop is guided by the forefinger of the left hand when introduced into the naso-pharynx. It is well to wear an india-rubber finger-guard whilst this is being done, to prevent injury from the teeth. In the case of large polypi attached by broad bases, it is advisable to cauterise the surface freely and deeply, so as gradually to destroy the tissues, if the growth cannot be removed with a snare. A solution of cocaine should be applied some minutes before the cautery is used, and one or more weeks should be allowed to elapse between each operation. After removal of a polypus, it is generally necessary to destroy with the electro-cautery the remains of the base, from which otherwise new growth may become developed.

It remains to add a few words on the third indication, viz., to restore the functions of the muscles of the Eustachian tubes. This effect is in some measure achieved by all remedies which improve the condition of the mucous membrane of the naso-pharynx.

Gargling the Throat, performed in the manner suggested by v. Tröltsch,* is an efficacious method of cleansing the naso-pharynx and of exercising and strengthening the muscles of the tubes. It is performed as follows:—The patient having taken a mouthful of the fluid, allows it to pass into the lower part of the naso-pharynx, and throws his head well back. The muscles of the palate and throat are then caused to contract, so that the fluid is forced upwards, and the motion of swallowing is then performed, but the fluid is not allowed to pass downwards. With a little practice, the same mouthful of water can be moved upwards and downwards before it is finally expelled from the mouth. A few tea-spoonfuls of brandy or a little borax may be added to the water. In order to show that this process causes the fluid to wash the pharynx, Dr. Roosa has suggested the following simple experiment:—Let the posterior wall of the pharynx be painted with tincture of iodine, and then a gargle of starch-water be used in the manner described; the characteristic reaction will be found in the ejected fluid.

---

* *Lehrbuch der Ohrenheilkunde*, Aufl. 6, S. 372.

The process causes forcible contraction of the muscles of the tubes; the glandular structures are compressed, and the muscles themselves are stimulated and strengthened.

Electricity is sometimes useful in these cases, and either the galvanic or the induced current may be employed. One electrode is passed either through the nose or into the mouth, and applied to the pharynx, while the other is placed on the side of the neck or in the meatus. (See last paragraph in chapter on Electricity in the Treatment of Diseases of the Ear.) In order to act directly upon the muscles of the tube, a suitable electrode may be passed into the orifice through the Eustachian catheter.

Adenoid Growths in the naso-pharynx play a very important part in the causation of diseases of the middle ear, and will therefore be described somewhat minutely. These growths generally spring from the pharyngeal tonsil, and are due to hyperplasia of its tissue. Owing to the nature of their structure, the term "adenoid" was applied to them by the late Dr. W. Meyer, of Copenhagen.

The pharyngeal tonsil was described by Kölliker in 1859, and he also discovered masses of glandular tissue around the openings of the Eustachian tubes, near the posterior nares and on the posterior part of the soft palate. Luschka states that the pharyngeal tonsil occupies the roof of the pharynx, extends thence to the posterior wall, forms the base of Rosenmüller's fossæ, and coats the surface of the swellings caused by the projecting mouths of the Eustachian tubes. Its normal maximum thickness is 7mm. It contains many roundish follicles and racemose glands; its structure is the same with that of the tonsils. In 1860 Czermak observed two small growths on the left side of the upper part of the naso-pharynx. In 1864 Sir Andrew Clark published a paper on naso-palatine gland disease, in the London Hospital Reports, and observed that fœtid cheesy masses were sometimes contained in the cavities of these glands. A year later, Löwenberg described three cases of deafness with vegetations in the naso-pharynx. Voltolini also reported the case of a man, aged forty, under his care during two years for deafness. He discovered stalactite-like growths projecting into the free cavity of the naso-pharynx. In 1868, Dr. Meyer gave a full account of adenoid growths in the *Medico-Chirurgical Trans-*

actions, vol. liii. He described the symptoms and progress of the affection, the microscopic character of the growths, and a mode of surgical treatment. He had then examined 2,000 children in national schools, and had discovered the affection in one per cent. of this number. In a London school containing 700 children, 13, or 1·8 per cent., were found by Dr. Meyer* to exhibit the "dead pronunciation." Digital examination proved that this was based throughout upon adenoid growths in the naso-pharynx. The close causal connection of ear-affections with these growths was likewise clearly ascertained by Dr. Meyer; he found 130 cases of ear-disease among 175 patients suffering from adenoid growths. A few years ago, Dr. Gustav Justi published an essay on this subject; it forms No. 125 of Professor Volkmann's "Sammlung."

Anatomically, the growths consist of adenoid tissue. They vary in form and consistence, sometimes being solid and firm—sometimes soft, highly vascular, and prone to bleed. They may be either almost uniformly distributed over the roof and posterior wall of the naso-pharynx, or collected so as to form several conical or comb-shaped projections. Dr. Meyer described them in one case "as giving the finger the sensation of soft masses, which, yielding to pressure, felt very much like a bunch of earth-worms, and, hanging down from the roof of the pharynx, completely closed up the posterior nares." On close examination, the surface of the growths is seen to be split in different directions, and dotted over with sieve-like lacunæ, which are formed by the openings of the excretory ducts of the mucous and follicular glands. The mucous membrane covering them varies in thickness; the epithelium is usually ciliated. Great vascularity is a characteristic of most of these growths; in some cases, the bulk of the tumour is made up of connective tissue. Microscopic examination reveals networks of delicate connective tissue, which in part contain lymphoid corpuscles, and in places are surrounded by them.

Etiology.—Adenoid growths are more common in young subjects than among adults. The great abundance of lymph-follicles in the naso-pharynx of children explains the frequent occurrence of the disease in early life; the usual period for these growths to declare themselves is about the third year. During childhood this lymphoid tissue is very easily excited to take on active growth. Similar examples are seen in the tonsils and cervical glands. The amount of tissue sufficient to cause marked symptoms in children might produce none in adults, in consequence of the larger space in the naso-pharynx allowing free nasal respiration; and for the same reason well-developed children may have a large amount of adenoid growth and yet keep their mouths almost closed. The excessive development of the tissue in question is probably often due to very slight catarrh of the naso-pharynx. It may be produced by prolonged congestion of this cavity, and hence the frequent development of growths after scarlet fever, measles, and whooping-cough. The absorption of septic matter by Luschka's tonsil may account for the frequent occurrence of growths after the two former diseases, and also for their development in weakly or underfed children, who pass much time in an overcrowded school, or who live in a small and badly ventilated room. *Sex* is apparently without influence in the production of the disease. *Heredity* is a doubtful factor, it being far more probable that the children affected have been exposed to predisposing conditions similar to those to which their parents were subjected. Tuberculosis is said to cause these growths, but they are not usually accompanied by other marked signs of the diathesis. In the majority of cases no obvious cause can be detected. The growths are not infrequently associated with deformities of the throat, such as cleft palate.

---

* *Archives of Otology*, vol. xiv. p. 267.

The **Symptoms** of adenoid growths may be divided into two classes—subjective and objective. The prominent subjective symptoms are (1) obstruction to nasal respiration; breathing through the nose is either impossible or very difficult. In the latter case the mouth can be kept closed, but only for a time, and it is more convenient to keep it open. The degree of obstruction depends upon the size and position of the growths and the size of the naso-pharynx, also upon the amount of swelling of the mucous membrane which they cause. When an infant is suffering from post-nasal growths he is unable to suck for more than a short time, and throws the teat out of his mouth frequently in order to breathe more freely. (2) Inability to blow the nose properly. The cause of this symptom is easily intelligible: air cannot be driven with sufficient force through the nares, so as to expel secretion. (3) The patient complains of dryness of the throat on waking; this is due to breathing through the mouth, the moisture of which is removed by the air. (4) Headache, which is doubtless due to the pressure or tension caused by the growths upon the mucous membrane, closely adherent to the base of the skull. To a like cause may be due the feeling complained of by many patients, that there is something at the back of the throat, which no attempts can remove. Meyer observed that this pain was increased in some cases by digital pressure on the growths; also that it was sometimes continuous, sometimes remittent, its locality varying in different cases; sometimes, and especially in children, there is abundant muco-purulent discharge, either oozing from the nostrils or trickling down the back of the throat. (5) Symptoms referable to the ear, viz., deafness, earache, and tinnitus; and, in some cases, more or less discharge.

About ten years ago, Dr. Guye,* of Amsterdam, drew attention to a symptom often associated with disorders of the nose and adenoid growths, and termed by him *aprosexia*, or inability to fix the attention on any definite more or less abstract subject. Most of the cases observed by him occurred among boys or young men at school or universities. In order to explain this symptom, Dr. Guye points out that large lymph-vessels leave the cerebral cavity together with the fibres of the olfactory nerve. Structural changes in the nasal mucous membrane, and especially such as exert pressure on the lymphatics, will prevent or hinder the current of the lymph, and cause retention of the products of metabolism in the cerebral tissues. Pressure on the lymphatics may likewise be caused by local hyperæmia, due to reflex action, which may serve to account for paroxysmal attacks of aprosexia.

A somewhat large percentage of disorders of the middle ear result from adenoid growths of the naso-pharynx. The catarrhal process accompanying the growths is very apt to extend through the tubes, especially when the growths are situated upon the lateral walls, close to the pharyngeal openings. Both ears are not always equally affected; the symptoms may diminish or even disappear for a time. The process in the middle ear is either acute or chronic, and corresponds with the intensity of the symptoms. When the ear-complication occurs, swelling of the mucous membrane of the Eustachian tube and interference with the passage of air to the tympanum are the first symptoms; afterwards the mucous membrane of the tympanum becomes involved. The patient often complains of auditory hallucinations of all kinds, such as ringing, buzzing, humming, and other noises in the ears; sometimes there are twinges of pain; range and sharpness of auditory perception are diminished.

---

* *Brit. Med. Journ.*, 1889, vol. ii. p. 709.

Objective Symptoms.—The patient has a heavy look, and appears dull and stupid (Fig. 91). The speech is decidedly affected; the sound of *b* is substituted for that of *p*, and *d* for *t*. In some cases the nasal sounds cannot be pronounced, but *b*, *d*, and *l* are uttered instead. The alteration in the voice is due partly to the closure of the nose, partly to alteration in the uvula, and diminution of the naso-pharyngeal space. Czermak was the first to show the importance of the uvula in the formation of vowel-sounds. He stated that when these are uttered, changes take place in the direction of the velum, and therefore in the level at which it closes the pharynx above. When adenoid growths exist, the velum is often thickened, partly in consequence of diffuse swelling of the follicular glands and partly from œdema. The weak, dull, monotonous voice is mainly due to the impediment to free movement, and to the thickening of the velum. After removal of the growths, the nasal twang may

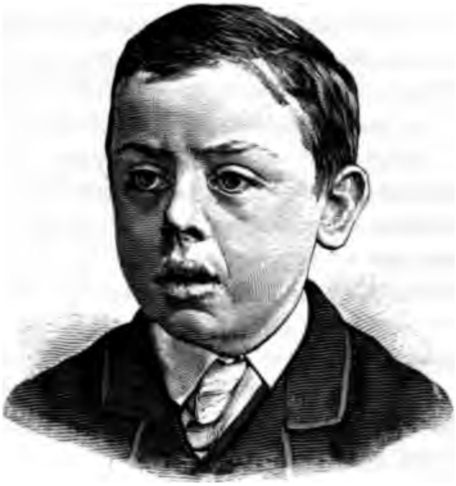


FIG. 91.

A BOY, AGED 14, THE SUBJECT OF POST-NASAL GROWTHS.

completely disappear, while the other features of the voice remain—probably as a result of thickening of the velum. As a matter of course, these growths interfere with singing, and may render it quite impossible. In addition to the mechanical obstruction which they cause, there is often paresis of the palate, due to the chronic congestion of the palatine glands and muscular tissue. In extreme degrees of enfeeblement of the muscles, the impairment of speech closely resembles that which occurs in patients suffering from cleft palate.

Other prominent symptoms, some or all of which may be present according to the severity of the case, are:—Noisy respiration when awake, snoring and sometimes also mucous dribbling from the mouth during sleep; the lips prominent and expressionless, and moving feebly, owing to partial abolition of the functions of the orbicularis oris, buccal respiration being often noticeable; excessive prominence of the central incisor teeth and a high vault of the palate; the nostrils narrow, a crooked septum, and the cavities of the nasal fossæ ill-developed; the alæ of the nose depressed at the junction of the superior and inferior lateral cartilages; the faucial tonsils often enlarged and sometimes persistent cough; distension of the transverse nasal vein, caused by obstruction to venous outlet through spheno-palatine foramina and pharyngeal collaterals. In severe cases the patients are often pigeon-breasted and present signs of anæmia. Nocturnal incontinence of urine is sometimes found in patients, especially girls, who are the subjects of adenoid growths.

Dr. William Robertson, formerly of Newcastle-on-Tyne, called attention to the presence or past existence of adenoid growths in cases of inflammation of the lymphatic glands in the neck, and was the first to point out that the latter affection was often directly due to the absorption of septic matter in the naso-pharynx. On examining the throat the hard palate is seen to be arched; its mucous membrane and that of the posterior wall of the pharynx are often swollen and almost œdematous in appearance. The growths in the naso-pharynx secrete a tough mucus, sometimes of greenish colour, which may be mixed here and there with blood; this runs down the posterior wall and the back of the soft palate. In adults the secretion is most abundant in the morning, having accumulated and become dry during the night. Exposure to cold causes increased secretion, which, if retained, is apt to become offensive, as a result of decomposition. The amount, colour, and consistence of the mucus found in the pharynx vary in different cases. The mucous membrane, as a rule, is deeper in colour than normal; the uvula is often twisted to one side. The back of the pharynx may present enlarged glands and vessels, projecting beyond the surface of the mucous membrane. *Pharyngitis sicca* may be found in cases where the obstruction affects only the upper and middle meatus. The larynx is often more or less congested.

On examining the ear, the membrana tympani is generally seen to be dull and depressed, often to an extreme degree; the bright spot is either diffused or absent. The membrane is sometimes congested, sometimes perforated; otorrhœa is not uncommon, and the cavity of the tympanum is sometimes occupied by granulations. The Eustachian tubes are generally closed to Valsalva's inflation.

Diagnosis.—In many cases the aspect of the patient is sufficient to enable a diagnosis to be made; but if there is a doubt, it may be removed by examining the naso-pharynx with a laryngeal mirror, or, failing that, with a finger. Digital examination is safe, easy, and practicable, and requires no preparation; it should never be neglected in any case at all suspicious. It is necessary to guard the finger from injury by the patient's teeth, and as the author found the jointed metal-guard in ordinary use unsuitable, he devised one of a different kind, figures and description of which will be found on page 114. Whilst the examination is being made the patient's head should be thrown a little backwards, and steadied with the surgeon's hand, and the patient should breathe quietly and deeply through the mouth. This digital exploration is practicable in patients of all ages. In the case of children, and in adults with small growths, not much interfering with the movements of the velum, the latter sometimes approximates to the posterior wall and impedes the passage of the finger. When this occurs, the tip of the finger should be placed behind the lower part of the posterior pillar of the fauces on the side on which the surgeon is standing, and slipped upwards in the space between it and the posterior wall of the pharynx. By this means it will easily pass behind the soft palate. Digital exploration informs us as to the consistence, size, and extent of the growths, which are more common than is generally supposed. Some amount of hæmorrhage usually follows the examination.

Inspection with the Mirror.—To diminish the irritability of the throat, the part should be first sprayed or painted over with a solution of cocaine, 2—5 per cent., according to the age of the patient. The mirror should then be passed behind the velum, to the front of the posterior wall of the pharynx, which should not be touched; it is then carefully turned, depressed, or raised, so as to get a view of the whole space. In some cases it is necessary to depress the tongue, but usually the examination is best borne when this is not done. By gently pulling the soft palate forward with a tractor the whole of the contents of the naso-pharynx can be seen. But this instrument is not well tolerated by children. When growths are present, and depend from the roof of the pharynx, their lower free border and posterior surface are all that can be seen. A better view can be obtained when there are only small growths on the roof and on the posterior wall. In adults with large growths, and in children, pharyngoscopy often partially or completely fails, from want of sufficient illumination, or on account of the narrowness of the space between the velum and posterior wall of the pharynx. Enlarged tonsils usually prevent a good view being obtained. When the nasal cavities are very large, it is sometimes possible to see the naso-pharynx by simply lifting up the tip of the nose. Such a view, however, can be obtained only in very rare cases. Zaufal's naso-pharyngeal speculum is sometimes useful, but difficulties in passing it are often encountered.

Adenoid growths may be mistaken for *nasal polypi*, *polypi filling the posterior nares*, and *retro-pharyngeal abscess*. Nasal polypi are generally accompanied by symptoms of nasal catarrh, sensations of fulness and discomfort in the nostril, and snuffling respiration. The sense of smell is deadened, and the nostril may become completely obstructed. Polypi can usually be detected on looking into the nostrils. The tumour presents a shining surface, and is greyish or greyish-yellow in colour; on touching it lightly with a probe, it is found to be soft, elastic, and movable; this last condition definitely distinguishes it from swollen mucous membrane. When the patient blows his nose, the growth is forced lower down. More or less of the tumour can be seen with a mirror or felt on digital examination, when it projects through the choana. Fibrous polypi cause symptoms of obstruction in the nose, and epistaxis is not uncommon. The tumour is apt to project into the pharynx as a hard, rounded mass, and afterwards manifests its presence in the nostrils. Such a growth usually springs from the roof of the pharynx and of the nasal fossæ, or from the inferior turbinated bone, but sometimes from the whole basilar surface of the sphenoid and occipital bones. The tumour has a firm consistence, and when visible is denser and more opaque than a mucous polypus. The symptoms of retro-pharyngeal abscess are sufficiently distinctive; the posterior wall of the pharynx is pushed forward by a collection of pus, which forms a tense elastic tumour, usually fluctuating distinctly and situated close behind the soft palate. It is generally caused by caries of the vertebræ, or suppuration of lymphatic glands at the back of the palate. In addition to pain and fever, there is more or less dyspnœa and cough, and frequent choking sensations. The rapid onset of the symptoms is sufficient to distinguish them from those of adenoid growths.

Treatment.—It is not necessary to operate when the growths are so few and so small that they produce no marked symptoms, and the hearing is unaffected; but when the symptoms become prominent an operation is imperative, irrespective of the age of the patient. The removal of adenoid growths may be required when a child is only a few weeks old in consequence of its inability to suck, on account of the nasal obstruction. An infant suffering from this affection throws the teat out of its mouth at short intervals in order to breathe. It has been stated that it is unnecessary to operate on patients who have passed the age of puberty, on account of the retrogressive changes which are taking place in the growth. This view is erroneous, because as long as the abnormal conditions remain which the growths cause, so long will the resulting mischief progress. The author has operated with marked benefit on many patients of more than twenty-one years of age. Shortly after operating on a gentleman twenty-seven years of age, he stated that since the operation his voice had been clearer than he ever recollected it to have been previously, and that for the first time in his life he was experiencing the comfort of being able to breathe through his nose. When operating at a patient's home, it is well to take precautions to ensure the clothes and couch being left unsoiled. With this object, the night-dress should be slipped down over the shoulders as far as the elbows, and a mackintosh laid not only beneath the head and shoulders, but also over the patient, and the middle of a towel should be placed behind the neck, and the two ends brought round, one on each side, then spread out and crossed in front. A folded wet towel should also be placed on the right side of the patient's face so that it may catch any blood which escapes from the mouth when the head is turned during the operation. It is well to protect the hair of the patient, especially if a girl, by means of a waterproof cap made of india-rubber or hat lining, and fitted with elastic, similar to a bathing cap.

When a patient has enlarged tonsils as well as adenoid growths, the tonsils may be removed with advantage at the same time. The precautions necessary to adopt whilst performing this operation when an anæsthetic has been administered, have been mentioned on page 290. For the removal of adenoid growths an anæsthetic should always be given, as the operation is somewhat painful, and children are naturally alarmed at the sight of blood; moreover, the author is of opinion that the operation cannot be thoroughly done whilst the patient is conscious. Not only should the growth be carefully removed, but in most cases it is necessary to snare off the posterior extremity of each inferior turbinated body by the method mentioned on page 285. For several years past the author has systematically taken away these enlarged extremities. He was led to adopt this course by noticing that nasal obstruction frequently remained, although all the adenoid growths had been carefully removed, and on investigating the matter he found that hypertrophied nasal mucous membrane was the cause of the continuance of oral respiration. Further examination showed the prevalence of enlargement of the posterior extremity of the inferior turbinated body, and led to the practice of its systematic removal. Owing to the frequency with which adenoid growths are met with, a large number of patients have to be operated upon at hospitals, and on account of the time occupied by the administration of the anæsthetics, there is a tendency amongst some surgeons to remove the growths without the patient being anæsthetised. When this is done, the same amount of care to take away all the growth cannot be exercised as when the patient is unconscious, and, moreover, the removal of the posterior extremities of the inferior turbinated bodies is not practised. It must not be forgotten that the naso-pharyngeal catarrh which accompanies these growths sooner or later spreads to the middle ear, and that the catarrh will continue unless all the growth is removed and nasal respiration thoroughly re-established. An absence of thoroughness must also occur when the removal of adenoid growths is performed with the patient merely under the influence of nitrous oxide gas; and, moreover, the patient experiences the fright and shock of seeing the blood, instruments, and arrangements for the operation which cannot be cleared away in consequence of the quick return to consciousness.

Whilst operating, the author prefers the patient to be lying on his back with a small pillow or folded bath-towel under his head; but the lateral position, in which the patient lies completely on his side, is a good one, and has the advantage of allowing all the blood to flow from the mouth. Some surgeons place the patient with his head hanging over the edge of the table; but the author disapproves of this posture, because it tends to interfere with respiration and coughing, and the extension of the head decidedly increases the hæmorrhage in consequence of the return of blood being retarded by the pressure exercised on the veins of the neck. He also deprecates the practice of placing the patient in a sitting position, as he considers the advantage claimed for it more imaginary than real, and without doubt the dangers are materially increased, especially if the anæsthetist has not had large experience.

General Anæsthesia in Nasal and Naso-pharyngeal Operations.* —Amongst the operations which may necessitate general anæsthesia, the following may be mentioned:—Removal of nasal polypi, turbinated bones and "spurs"; straightening of the septum nasi; removal of the posterior extremities of inferior turbinated bodies; removal of post-nasal adenoid growths;

---

* The paragraphs under this heading as far as page 317 have been written especially for this work by my friend, Dr. Hewitt, whose large experience in the administration of anæsthetics entitles him to be regarded as one of the leading authorities on the subject.

removal of the tonsils; application of the electro-cautery to various parts of the nasal or naso-pharyngeal passages.

(1) **The Preparation of the Patient.**—This becomes a matter of considerable importance in operations of this kind; for it is exceedingly inconvenient for retching or vomiting to arise during the administration of the anæsthetic. As a general rule, a purgative should be given the night but one before the day fixed for the operation, and an enema on the morning of the operation. If these precautions be not adopted, the straining or coughing incidental to the return of consciousness may induce undesirable effects. Speaking generally, no food should be given for five hours prior to the operation; and, whenever practicable, the latter should be performed at or about the time that a patient would, under ordinary circumstances, be taking a meal. Milk should be avoided both before and after the anæsthetic. For early morning operations, *i.e.*, for those up to 10 a.m., nothing whatever should be taken after the usual meal of the preceding evening. If the administration be fixed to take place about 12 o'clock, a cup of tea or coffee, with a single piece of toast, or a biscuit, may be allowed at 7. When the case is arranged for 1 or 2 o'clock, a light breakfast at 8 or 9 may be permitted.

(2) **The Selection of the Anæsthetic.**—Generally speaking, the "gas"-ether-chloroform sequence is to be preferred to all other means for inducing and maintaining anæsthesia. Nitrous oxide is of special value, because it cuts short the crying of intractable children, and the semi-conscious stage so dreaded by nervous adults. In private houses there are generally relatives within ear-shot, and it is important, for their sake, that the noise and excitement so common with certain methods of administration should be avoided. Ether is essential, because one cannot pass direct from nitrous oxide to chloroform, and because, owing to its stimulant effect upon the circulation, it allows the patient to pass safely through the stage of rigidity. When once this stage has been passed, and the patient has been thoroughly etherised, anæsthesia may be advantageously maintained by means of chloroform. In some short operations it will not be necessary to give chloroform at all; but when anything more than two or three minutes' anæsthesia is needed, chloroform is more or less essential. There are certain subjects, however, in whom this particular

sequence of anæsthetics needs modification. For example, in the very young and the very old, nitrous oxide is not to be recommended. In infants and young children, anæsthesia may be induced by A.C.E., and continued by chloroform; or, the A.C.E. may be followed by a small quantity of ether prior to chloroform; or, ether may be given from the first upon a simple little felt cone, and chloroform subsequently administered. Patients above sixty-five years of age are also best anæsthetised by the A.C.E. mixture, chloroform being substituted when deep unconsciousness has been produced.

Speaking generally, nitrous oxide *per se* is not a satisfactory anæsthetic for operations of this class, although it may be selected under special circumstances. The best form of nitrous oxide anæsthesia is undoubtedly that obtainable when this "gas" is administered mixed with oxygen; and, when thus given, an average available anæsthesia of about forty-five seconds may be relied upon in adult patients. The chief objection to the comparatively short anæsthesia of nitrous oxide is that the operation must necessarily be somewhat hurried, and that should any unforeseen difficulty arise, the circumstances are necessarily unfavourable for meeting it. It is far better to have a reserve of anæsthesia, so to speak, even at the expense of slightly upsetting the patient by the deeper and more protracted unconsciousness. One argument which has been brought forward in favour of nitrous oxide in these operations is its great safety; but if the administrator be competent and experienced, there is no greater risk in giving "gas" and ether than "gas" alone; whilst the comfort of the operator in feeling that he is not hurried, and the absence of all reflex noise and movement during the operation, are points which are greatly in favour of the longer anæsthesia. As many of these patients breathe abnormally and possess deformed upper air-passages, they are particularly liable to be rapidly asphyxiated by nitrous oxide, and to exhibit so much muscular twitching and jaw-spasm that considerable difficulty may arise in the performance of the operation. Space will not permit of reference to the various morbid conditions which call for special departures from these customary methods.

(3) **Posture.**—The posture of the patient is of the utmost importance in these operations, and the anæsthetist must be prepared to keep up anæsthesia with the patient placed in any

position that the surgeon may require. At the same time, there are certain postures which are very convenient from the anæsthetist's point of view, whilst there are others in which it is very difficult to keep up satisfactory and safe anæsthesia. There can be no doubt that, so far as smoothness in anæsthesia is concerned, the purely lateral posture is the best; but, unfortunately, many surgeons find it inconvenient or impossible to operate when the patient's body is thus adjusted. In the lateral posture, all embarrassment to breathing from the presence of blood, etc., is prevented; for everything flows into the lower cheek, from which it may be easily removed.

The posture usually preferred by Mr. Mark Hovell is the purely dorsal, with the head, but not the shoulders, very slightly raised by means of a thin pillow or folded towel. It may, at first sight, seem that such a posture is open to serious objection, owing to its not providing for the escape of blood; but when certain simple precautions are adopted, this objection practically ceases to exist. These precautions are as follows:—In the first place, relays of small and roughly spherical sponges, with open meshes, are needed; secondly, the head is always turned to one side in the event of hæmorrhage becoming excessive; thirdly, the head is never allowed to become extended; and, fourthly, the depth of the anæsthesia is so adjusted that swallowing and coughing movements are not abolished. The sponges employed should be carefully chosen. They should not be attached to handles, and they should not be too fine; otherwise, they will not remove small clots from the pharynx. Turning the head to one side, for a few seconds at a time, hardly interferes at all with the course of the operation. Extension of the head over the end of the couch or table, although still regarded by some as having advantages, is, in our judgment and experience, distinctly open to objection. Not only does it render swallowing and coughing movements difficult or impossible, but it tends to increase hæmorrhage by causing pressure on the vessels of the neck, and thus retarding the flow of blood from the head; and, if the nasal passages be obstructed, considerable embarrassment in breathing may result. When the depth of anæsthesia is properly graduated, so that slight coughing and swallowing occur, and when these other little precautions are taken, the dorsal posture may be safely chosen.

With regard to the sitting position, a great deal may be said. It should certainly not be selected except by an experienced administrator, and certain precautions should be observed. The patient's head should be kept in a line with the body; deep ether anæsthesia should be induced before the operation is begun; a slight return towards recovery should then be permitted; and the anæsthesia subsequently maintained by chloroform, care being taken, as in the dorsal posture, to maintain the swallowing and coughing reflexes. Should hæmorrhage be free when the patient is thus placed, he should either be bent forward for the escape of blood, or sponging must be assiduously practised. There are some patients in whom laryngeal sensibility seems, to a certain extent, blunted; and care must be taken in anæsthetising them, lest the unconsciousness become too profound, and blood noiselessly accumulate at the rima glottidis. The worst postures of all are the semi-recumbent and the dorsal with extended head; these should always be avoided.

(4) **The Administration.**—As the commonest of the operations now under consideration is that for the removal of adenoid growths, it may be well to consider this in some detail. Supposing the patient to be a child of 10 or 11 years, the best mode of procedure is as follows:—The patient should be examined with the object of ascertaining whether any respiratory or circulatory affection is present, and the oral cavity should be inspected and loose teeth carefully noted. (It is not an uncommon thing for loose teeth to be dislodged by the use of a Mason's gag; if, therefore, such teeth be present, special care must be exercised to avoid this accident.) The patient should be asked to close his lips and breathe through his nose, with the object of ascertaining to what extent the nasal air-way is occluded. Should nasal respiration be difficult or impossible, special care must be exercised; and, *on no account* should nitrous oxide be given, unless a small mouth-prop be previously placed between the incisor teeth. There are some children whose breathing is so much obstructed by enlarged tonsils and post-nasal growths, as to render even natural sleep a matter of difficulty; and, in such cases, it is, perhaps, better to avoid nitrous oxide, and to induce anæsthesia with the A.C.E. mixture. I have indeed met with several such cases. The patient should lie upon his back, with the head very slightly raised and turned to one side. Nitrous oxide should be given

in the customary way, till stertor commences, or till two or three stertorous breaths have been taken, when one inspiration of fresh air should be permitted, and Ormsby's ether inhaler, charged with ether, should then be loosely applied. Patients of this class may easily become asphyxiated by nitrous oxide before they are fully anæsthetised, so that, when the ether inhaler is applied, there may be a transient stage of muscular movement, needing slight restraint. This can hardly be avoided unless the administrator push the nitrous oxide to an undesirable degree. Respiration is generally "held" when the Ormsby inhaler is applied; but it soon becomes re-established, and ether anæsthesia supervenes, air being admitted as occasion may require. The breathing now becomes regular, moist, and deep in character.

If it be desired to remove the tonsils before the adenoid growths, ether should be administered two or three minutes before the operation is begun; otherwise, there may be some inconvenient rigidity and tendency towards recovery during the removal of the second tonsil. If, however, the patient be deeply anæsthetised by ether, there will be time for clearing the fauces of mucus, inserting a Mason's gag, changing the gag to the opposite side, if occasion should require, removing both tonsils, and sponging away blood before the patient shows signs of return towards semi-anæsthesia. Directly the tonsils are removed, the patient is placed again in the recumbent position. In any case, it is a good plan, when the tonsils have been dealt with, to allow the corneal reflex to return, so as to be certain of one's landmarks before continuing the anæsthesia by means of chloroform. The best way to maintain anæsthesia is to use a Mason's gag for keeping the mouth open, and to pass the bent metal mouth-tube of a Junker's inhaler to the back of the mouth. Should any difficulty in breathing arise, as it often does, from opening the mouth widely by the Mason's gag, the latter should be somewhat relaxed. If the anæsthetist prefer it, he may use a special Mason's gag already fitted with a tube for the transmission of chloroform vapour to the back of the throat. From this point onwards slight corneal reflex should, as a general rule, be preserved.

In the case of older patients, nitrous oxide and ether must not be given in the manner just mentioned, inasmuch as asphyxial troubles would almost certainly arise during the transition from the one to the other anæsthetic. The plan which answers best in these cases is to adapt the gas-bag to a Clover's portable inhaler, and gradually to mix the two anæsthetics. The most difficult patients are healthy and vigorous young men and women—those whose muscular systems are in a good state of development—and such patients will require a somewhat deep form of anæsthesia in order to avoid inconvenient rigidity. If the sitting posture be chosen, nitrous oxide and ether must not be given by any method involving a change of inhalers, but the two anæsthetics must be gradually mixed. As already mentioned, special care is necessary in keeping up chloroform anæsthesia in this position, and Junker's inhaler answers well. Should hæmorrhage be very free, the whole body may easily be tilted forwards from time to time, and special care must be exercised to avoid too deep an anæsthesia. Patients vary very considerably as to the degree of laryngeal sensitiveness they display. In some, a more or less constant, but slight and not inconvenient, cough may persist throughout; in other words, the larynx will protect itself most efficiently. But in other subjects, even though the corneal reflex be present, the larynx may become quietly and noiselessly invaded by blood, so that most careful attention is necessary throughout, and frequent sponging should be practised. When the electro-cautery has to be applied, the patient should have been breathing chloroform for several minutes; otherwise, there may be risk from the inflammability of ether vapour.

A brief reference may be made to certain useful appliances in these operations. Two sizes of Mason's gag are needed—one for adults and one for small children. The gag for adults should be strong, and furnished with a movable flattened ring, working over a toothed surface. The best form of Junker's inhaler is one which has its efferent rubber tubes passing through the afferent or bellows tube. The metal mouth-tube should be of large calibre.

(5) **Management of the Patient after the Administration.**—Immediately the operation is over, the patient should be placed in the most favourable posture for drainage. Should the operation have been performed in the dorsal position, he should be turned upon his side, the Mason's gag remaining *in situ*, with the mouth slightly but not too widely open, till distinct signs of

recovery begin to assert themselves. It is a good plan to flex the knees, in order to prevent the patient rolling on to his back, and to bring the *upper* limb a little in front of the lower, so as to give a slightly forward inclination to the whole body, at the same time placing the lower shoulder well back, in order to ensure this position being maintained.

If the patient has been in the sitting position, he should be placed on his side when the operation has been completed. In fact, the *lateral* posture is the only permissible one after these operations. It does not follow that because the operation has been completed, and the reflexes have begun to return, that the patient should be left to himself. There is indeed a distinct risk of self-asphyxiation during recovery from anæsthesia, and if the patient be allowed to lie in the dorsal position, this risk will be increased. Besides this, breathing will be more embarrassed with the mouth very widely open than with the lips brought nearer to each other. Again, the Mason's gag must not be entirely removed till the patient has shown distinct signs of recovery, otherwise clenching of the jaws and general blocking of the pharynx during incipient vomiting may initiate serious difficulties. Patients should never be left for a moment during the recovery stage.

As some blood is invariably swallowed during these operations, one or two acts of vomiting are common before consciousness is fully established. Some patients exhibit rather curious symptoms whilst they are gathering up, so to speak, the necessary force for the act of vomiting; they become rather pale, or livid, with shallow respiration and rather feeble pulse, but the corneal reflex is present. By briskly rubbing the lips, both inside and out, with a soft cloth, coughing or vomiting will generally ensue, and this curious condition will vanish. When once distinct signs of recovery have come about, the patient should be allowed to sleep off the effects of the anæsthetic, the lateral posture still being maintained. No nourishment should be given till the patient shows a distinct inclination for it. As a general rule, a little clear soup, or some "Brand's essence" may be then given; some patients prefer a little tea or coffee, more especially after comparatively slight operations.

Removal of the Growths.—For the removal of the growths, either forceps or a curette is usually employed. The author prefers forceps, because he considers that they remove the growth more thoroughly than a curette, which, from its shape, is especially liable to leave untouched growths attached to the anterior part of the roof of the naso-pharynx. The best curette is Delstanche's modification of Gottstein's, the addition being a hinged box furnished with hooks which catch into the growth and retain it when it has been severed by the cutting edge. Except in experienced hands, a very small instrument of this kind is safer than forceps for removing adenoid growths from infants, as in these cases there is not room in the naso-pharynx for the forceps to be guided by a finger. An instrument for scraping, whether attached to a handle or fitted to a finger, is to be regarded as unsuitable, because of the injury to the surrounding healthy tissues which is liable to result from its employment, and also the unnecessary damage caused to the tissues lying beneath the surface to which the growths were attached.

In order to avoid unnecessary hæmorrhage, the edge of the forceps should not be too sharp. Löwenberg's forceps and the various modifications thereof appear to present two defects. In the first place, only a portion of the end of the instrument has a cutting edge, and hence it is often impossible to cut off the piece of growth held between the blades. The portion not cut away has to be torn off, and when the growth is thick and tough, the tearing sets up more inflammation than would otherwise have occurred. It is generally stated that the cutting edge is made only on the upper and posterior part because the growths are, as a general rule, attached exclusively to the upper and posterior walls of the naso-pharynx, and that a sharp edge is required only in those situations. The statement as to the attachment of the growths is correct, but the deduction is erroneous, because the piece of growth grasped by the forceps is frequently larger than the end of the instrument, and has an attachment greater than the length of its cutting edge, and a larger surface from before backwards than that covered by the blades. It is therefore evident that such a piece cannot be entirely removed, without being partially torn away, by the instruments hitherto employed. The second defect is that the two cutting edges are made to strike against one another, and consequently soon become extremely blunt. In the instrument which was manufactured for the author by Mayer & Meltzer, in 1887, and exhibited that year at the meeting of the British Medical Association at Dublin, both the defects mentioned above have been remedied; the first, by the entire circumference of the blades being made with a cutting edge; the second, by one cutting edge being made to pass inside the other, so that the piece of growth grasped by the forceps is completely detached by the action of the instrument. The end of the latter has also been fenestrated to prevent a thick piece of the growth from interfering with the close approximation of the blades.

When the proper amount of anæsthesia has been produced, the surgeon, standing on the right side of the patient, should insert the first finger of his left hand, with the palm upwards, into the naso-pharynx, and feel the growth. The forceps, held in the right hand, should then be introduced, the left forefinger not only holding forward the soft palate out of the way of the forceps, but also serving as a guide to the growth to be removed. The blades should then be opened, and the growth gripped, the left forefinger, if necessary, pushing the growth between them. Unless it be of firm consistence, it is best partly to cut and partly tear it from its attachment by a slightly oscillating movement of the forceps, the tip of the forefinger of the left hand at the same time gently assisting to separate the growth from its attachment should it not readily come away.

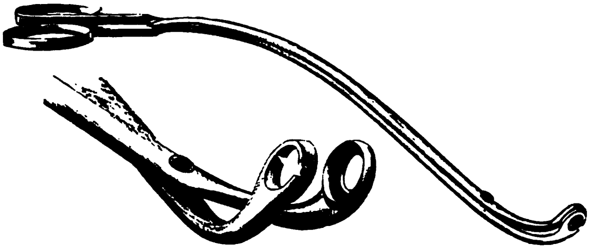


FIG. 92.

THE AUTHOR'S POST-NASAL FORCEPS.

The screw which is represented as holding the blades together is now replaced by a pivot, an arrangement having been added which allows the two blades to be taken apart for the purpose of cleaning them.

Care should be taken to prevent traction on any portion of mucous membrane which may happen to remain unsevered, for strips are sometimes torn away in consequence of this detail being neglected.

When that piece of growth has been removed, the forceps should be again inserted into the naso-pharynx, the left forefinger being still in that region. The remainder of the growth should then be felt for with the finger, and removed by the forceps, until all has been taken away. The left finger should remain on each piece of growth until the closure of the blades of the forceps makes its removal necessary; by this means no injury can be done to healthy tissues. Each piece of growth, as it is removed, is most easily detached from the forceps by shaking the latter in water.

As the pharyngeal extremities of the Eustachian tubes are at the sides, no harm can be done to them if the patient's face look directly upwards, and the curved end of the forceps be kept in the mesial line. Two cases in which the vomer was injured have come to the author's knowledge; but this is an accident which could not occur if ordinary precautions were taken.

Before completing the operation the left forefinger should be inserted into each choana in order to ensure that no portion of growth is left attached to its upper border, each fossa of Rosenmüller should also be examined, and any small piece of growth which remains in the naso-pharynx should be removed by scraping it off with the finger-nail.

It may be necessary to stop during the operation in order to take away the blood which has collected, and for this purpose it is best to use pieces of soft honeycomb sponge, about two to two-and-a-half inches in each diameter. A fine sponge is comparatively of little use for this purpose, as its surface becomes coated with mucus, and it does not remove the clots. About a dozen pieces of sponge are required. Each piece should be carried to the back of the mouth on the second finger of the right hand, then swept across the lower part of the pharynx and removed. If an assistant pass a clean sponge with one hand, and take the used one with his other hand, several sponges can be used in very quick succession. Care must be taken not to hand more than one sponge at a time, otherwise the second may be left in the patient's throat without its presence being immediately discovered. Sponge-holders are not only unnecessary, but inconvenient, as the pharynx can be more effectually and more rapidly sponged out as above described.

In most cases, as soon as the growths have been removed, the hæmorrhage quickly subsides. In the rare cases in which it continues, the nostrils should be filled with ice, and in the event of that failing to arrest the bleeding, pressure should be made with a sponge on the place from which the growths have been taken away. Ergotine may also be administered hypodermically. In the rare event of the uvula becoming œdematous, it should be scarified with the uvula scarifier (Fig. 89) before the patient regains consciousness; but if this condition does not occur until after the operation has been concluded, a 5—10 per cent. solution of cocaine should be applied before the œdematous tissue is pricked.

Unless there are indications of a collection of septic matter, it is best not to spray lotions into the naso-pharynx or throat for a week or ten days after the operation, as the straining and coughing which is liable to result does not assist the healing processes. When sufficient time has elapsed for the parts to have thoroughly healed, the ordinary treatment for naso-pharyngeal catarrh should be adopted, and, when necessary, air injected into the middle ear.

The hypertrophic rhinitis which often accompanies post-nasal growths usually subsides when the latter have been removed; but should it continue to produce nasal obstruction, in some cases the lax tissue may be touched with the electro-cautery with advantage. This treatment, however, is not desirable when dealing with children. Recurrence of the growths after removal is the exception and not the rule; and when it occurs, the growths are but rarely developed to the same extent which they were originally. Recurrence results from a continuance of the congestion of the naso-pharynx, and is more common in delicate children than in those of robust health. As the fresh growths tend to keep up naso-pharyngeal catarrh, their removal may be rendered necessary on account of the condition of the ears, and in this case the operation must be performed as on the first occasion.

The patient should be directed to discontinue the habit of keeping the mouth open, and made to practise breathing through the nose. Considerable perseverance is necessary in some cases for this change to be effected; but it must be borne in mind that the continuance of the symptom may be due to the recurrence of its original cause, and not to forgetfulness or obstinacy on the part of the patient.

CHAPTER XXII.

AFFECTIONS OF THE EUSTACHIAN TUBE.

Extension of Morbid Processes through the Eustachian Tube—Injuries to the Eustachian Tube—Foreign Bodies—Inflammation of the Eustachian Tube — Anatomical Appearances — Symptoms — Examination of the Throat and Ear—Treatment—Constrictions of the Eustachian Tube — Diagnosis — Complete Atresia — Undue Patency—Ulceration of the Eustachian Tube—Diphtheria, Small-pox, Tuberculosis, and Syphilis — Treatment of Constrictions, Abnormal Patency, and Ulceration.

EACH Eustachian tube consists of two portions, a cartilaginous and an osseous (see p. 50), and these are connected by an isthmus, the narrowest part of the tube. The cartilaginous portion may be regarded as a prolongation of the naso-pharynx; its mucous membrane is continuous with that of the latter cavity, in which its disorders are wont to originate. The osseous portion is similarly connected with the cavity of the tympanum, and hence disease of one structure is usually associated with a similar condition of the other. The Eustachian tube is the only channel of communication between the tympanum and the external air, and by it, also, in the majority of cases, morbid matters gain access to the cavity. There are two ways in which disease may spread from the naso-pharynx to the tympanum: (1) by extension of inflammation along the mucous membrane of the tube; (2) by the passage, in a similar direction, of infectious secretions during forced expiratory movements. On the other hand, as a far less frequent occurrence, disease may extend in the opposite direction, viz., from the tympanum to the Eustachian tube, and thence to the naso-pharynx. In all those affections of the Eustachian tube which are attended by swelling of the soft tissues, increased secretion or exudation, the tympanum is liable to be implicated, not only as a result of extension of the morbid process, but because the ventilation of the cavity becomes obstructed, and the escape of secretions is retarded or altogether checked.

INJURIES TO THE EUSTACHIAN TUBE—FOREIGN BODIES.

Owing to its sheltered position, the Eustachian tube is rarely the seat of injury; its mucous membrane is sometimes torn during unskilful attempts to pass a catheter. A few cases of gunshot wound have been placed on record. Obliteration of the canal is, of course, the ordinary result. In a case of punctured wound,* the knife passed through the cartilaginous portion of the meatus, below the articulation of the jaw, into the pharynx, dividing the cartilaginous portion of the Eustachian tube. Recovery took place, with atresia of the tube as the result.

Foreign bodies very seldom gain access to the Eustachian tube. During the act of vomiting, matters from the stomach have been known to pass into the pharyngeal orifice. Breakage of bougies, used to dilate the tube, has in a few cases been followed by the lodgment of fragments. These set up vomiting, which may cause their expulsion. In one case, a barley-corn was found in the tube on post-mortem examination.† The man had complained of noises in the ear for some time before his death. In a very remarkable case, under the care of Dr. Urbantschitsch,‡ an oat-husk, 3cm. in length, passed into the pharynx and thence along the Eustachian tube into the tympanum, where it set up purulent inflammation. Nine weeks afterwards it was discovered in the external meatus, the membrana tympani having become perforated. While the husk was passing along the tube, the patient experienced very severe pain in moving the jaw, and for several weeks could take only fluid nourishment. There was also total loss of appetite, possibly due to irritation of the branches of the pneumogastric supplying the tube.

---

* *Berlin. Klin. Woch.*, 1883, No. 40.

† Linke's *Abhandlungen*, II. S. 182.

‡ *Lehrbuch der Ohrenheilkunde*. III. Aufl. S. 202.

Foreign bodies of another kind are occasionally found in the tube. Intestinal worms have been known to pass upwards into the throat, and thence along the Eustachian tube into the tympanum* and external meatus.

During bathing, water sometimes passes along the Eustachian tube and reaches the tympanum, in some cases setting up violent inflammation. The employment of the nasal douche is liable to be followed by similar consequences (see page 275). In a case recorded by Schalle,† a fragment of a new india-rubber syringe, used for cleansing the naso-pharynx, passed through the tube into the tympanum, whence it was extracted three days later, after paracentesis of the membrane.

INFLAMMATION OF THE EUSTACHIAN TUBE.

Catarrhal inflammation of the Eustachian tube often accompanies catarrh of the naso-pharynx. The process is then most severe in the cartilaginous portion, and may be confined to it. Less frequently inflammation spreads from the tympanum to the osseous portion of the tube. As a matter of fact, the tubes are affected in almost all diseases of the middle ear; they are, indeed, the channels through which infection extends, and hence inflammation of these parts is of very common occurrence. It rarely happens that the process is confined to the tubes; but cases of this kind do sometimes occur, and usually in children. In young subjects the mucous membrane is thick and the cartilage ill-developed, and hyperplastic processes are easily set up. In addition, the pharyngeal orifice is narrow, and secretion is very liable to be retained. Tuberculosis is a predisposing cause, and this condition is sometimes associated with adenoid growths and hypertrophy of the tonsils.

The **Anatomical Appearances** are redness, swelling, and increased secretion. The tube is filled with a muco-serous or more or less purulent fluid; the blood-vessels are enlarged and tortuous, and the mucous membrane is swollen, owing to cellular and serous infiltration. In some cases the secretion is very tenacious in character, and closely adheres to the walls of the tube, so as completely to obstruct it. Sometimes a whitish-yellow plug may be seen projecting from the pharyngeal orifice, and a complete cast of the tube may be formed by inspissated secretion. In other cases, the exudation is fluid in character, and more or less purulent. It always contains cylindrical epithelial cells, some being ciliated; and micro-organisms of various kinds are frequently present. Dr. Macewen points out that purulent inflammation of the tympanic cavity may extend into the Eustachian tube, in the walls of which an abscess may form and ultimately produce gravitation abscess in the naso-pharynx. Also in cases of tuberculous disease of the tympanum, pus may escape from the pharyngeal orifice of the Eustachian tube. A similar discharge is sometimes witnessed in non-tuberculous cases.

---

* Lewis Reynolds, *Lancet*, vol. ii. 1880, p. 653, and Wagenhäuser, *A.f.O.* xxvii. S. 166.

† *Arch. f. Ohrenheilkunde*, vol. x. p. 372.

Symptoms.—A patient suffering from inflammation of the Eustachian tube on one side complains of a sensation of pressure and fulness in the ear, of tinnitus, and of more or less deafness. These symptoms are well-known accompaniments of an ordinary cold. The patient is apt to regard the deafness as more severe than is really the case; he feels as though the meatus were plugged up. When the inflammation is very severe, pain in the ear is generally superadded; it may extend to the angle of the lower jaw and side of the neck, and it is made worse by movements of swallowing. Giddiness and nausea are sometimes observed. Sudden disappearance of all the symptoms is occasionally noticed; it generally occurs during eating, and is caused by the opening of the membrano-cartilaginous portion of the tube, or perhaps by the escape of inspissated secretion. The improvement, however, is only temporary; the symptoms connected with the ear speedily return. Not infrequently, the opening of the tube is accompanied by a crack, of which the patient is conscious.

On examining the throat by posterior rhinoscopy, the appearances are those already mentioned, viz., circumscribed redness of the mucous membrane with increased secretion, swelling, and contraction of the orifice, which is sometimes occluded by a plug of tenacious secretion. Considerable resistance is offered to the passage of the Eustachian catheter, nd when the beak of the instrument is within the lips of the tube, several compressions of the bag may be required before air begins to pass. The obstruction may be caused by swelling or by folds of the mucous membrane, by thick, tenacious secretion, or by adhesion of the walls of the tube. When it is overcome, the sound heard on auscultation is weak, distant, and interrupted; but by degrees it becomes stronger, nearer, and more continuous. If the obstruction be completely removed, the sound approximates to its normal blowing character.

On examining the ear, in cases in which the Eustachian tube has been for some time impermeable to air, the appearance of the tympanic membrane is seen to be materially changed. The funnel-shaped depression is increased in depth, and the handle of the malleus is decidedly shortened. These alterations are due to the rarefaction of air in the tympanic cavity; the atmospheric pressure on the external surface of the membrane is greater than on the internal. Besides the increased concavity of the membrane and the shortening of the handle of the malleus, the folds (especially the posterior one) passing from the short process are rendered more prominent, while the cone of light is much diminished in size, or even obliterated. As the membrane is drawn inwards, the angle between the handle of the malleus and the posterior fold becomes more and more acute, and the short process is caused to project downwards, like a peg, towards the external meatus. In very marked cases, the promontory, the long process of the incus, and the chorda tympani nerve sometimes become visible.

Chronic catarrh of the Eustachian tube is a not infrequent result of an acute attack, and often accompanies adenoid growths and chronic nasal catarrh in young subjects. Pain may be altogether absent; but deafness, due to the closure of the tube, becomes a more prominent symptom. The mucous membrane undergoes various changes, such as thickening of the epithelial and subjacent layers, and development of connective tissue. The changes in the tympanic membrane become more and more marked. In a small proportion of chronic cases, atrophy of the mucous membrane takes place, and results in enlargement of the calibre of the tube.

Treatment.—Measures must be adopted to cure or relieve the morbid condition of the naso-pharynx. For this purpose, the various remedies, as described in a preceding chapter, may be employed in the form of gargles, inhalations, sprays, and pigments. Constitutional treatment is always required; cod-liver oil, iodide of iron, arsenic, and other tonics are likely to be useful. To relieve the condition of the Eustachian tube and tympanum, the catheter and air-douche must be employed. If the local treatment of the naso-pharynx prove insufficient, weak lotions should be injected into the Eustachian tube through a catheter. To ensure the fluid being warm, it is well to make the solution which is to be employed of double strength, and dilute it with an equal quantity of hot water before use. Care should be taken that the nozzle of the syringe does not fit the catheter too closely, otherwise the fluid may be forced along the Eustachian tube into the tympanum, and produce inflammation of that cavity. The patient's head should be placed, if possible, against a rest, and held straight, so that the stem of the catheter when in position may be horizontal. Two or three drops of fluid should then be put into the catheter from the syringe, and blown into the Eustachian tube by a handball previously attached, ready for use, to the button of the coat. The auscultation tube should be in use whilst this is being done, so that the pressure upon the air-bag may be properly regulated according as to whether or not the fluid is passing readily into the Eustachian tube. The injection should be repeated two or three times a week, or daily for a short time in severe cases. If a 2 per cent. solution of cocaine be sprayed through the nostril before the catheter is passed, the discomfort which sometimes attends its passage will be prevented. In many cases alkaline solutions are best. Iodide of potassium (about 10 grains to the ounce) is very useful; and bicarbonate of soda (3—5 grs. to the ounce) may also be employed with advantage. When an astringent is required, it should be weak. A solution of sulphate of zinc (1 grain to the ounce) will prove beneficial.

CONSTRICTIONS OF THE EUSTACHIAN TUBE.

The calibre of the Eustachian tube may be diminished at various points and from a variety of causes. Thus the pharyngeal opening may be partially closed by enlargement of the pharyngeal tonsil, by tumours* in the neighbourhood, and by the cicatrisation of ulcers due to syphilis, tuberculosis, or diphtheria. Constrictions in the tube are the result of thickening of the submucous connective tissue, as may occur after repeated attacks of inflammation. Apparent constriction is sometimes due to an abrupt bend in the tube, or to projection of the carotid canal into the osseous portion. Constriction in this latter may be due to hypertrophy of the mucous membrane, to connective tissue formation during middle-ear inflammation, or to bands of the same tissue extending between the walls of the tube. Besides these causes of constriction, the osseous portion may be more or less blocked up by bony deposit and exostoses.

The **Diagnosis** of constriction of the Eustachian tube is effected by means of rhinoscopy, the air-douche, and also by inspection of the membrana tympani. The use of bougies for this purpose is not recommended by the author (see page 140). The condition of the pharyngeal orifice should always be carefully examined; adenoid growths, enlargement of the pharyngeal tonsil, and growths from the inferior turbinated bone may constitute the obstacles to the passage of air. It must also be remembered that constriction in the tube itself may coexist with any of these impediments. There are other conditions which play a more or less decided part in diminishing the patency of the Eustachian tube. Among them may be mentioned atony and insufficient action of the muscles of the palate, due to over-exertion of these parts, or the result of paralysis after diphtheria. A similar condition of the muscles is sometimes noticed during recovery from exhausting illnesses, in cases of anæmia, and occasionally as a result of old age.

Complete Atresia of the tube is a rare condition; it may be caused by those processes which produce constriction. In the majority of cases, the occlusion exists at the pharyngeal orifice. Cicatricial stricture and complete obliteration of the canal have been observed in cases of syphilitic and diphtheritic ulceration. The symptoms are similar to those of severe inflammation of the tube: there is an unpleasant sensation of fulness and pressure in the ear, together with tinnitus, headache, giddiness, and loss of hearing-power. The rarefaction of the air within the tympanum produces hyperæmia of the mucous membrane and transudation of serum. The membrana tympani is drawn inwards, and no sound is heard on injecting air through the catheter. Various alterations may be discoverable on posterior rhinoscopy.

---

* *Journal of Laryngology*, April, 1895, p. 326. Case of fibrous sarcoma of the pharyngeal orifice of the Eustachian tube.

An opposite condition of the tube, viz., undue patency, is sometimes present. It may be due to senile atrophy of the parts, to atrophy of the mucous membrane following chronic catarrh, or to destructive ulceration. It is sometimes temporarily present in cases of extreme debility, but is generally associated with atrophic conditions of the nose and pharynx. Partial dilatation most often occurs at the pharyngeal orifice. In one case, recorded by Urbantschitsch,* the tip of the little finger could be easily introduced into the mouth of the tube. As results of the undue patency, air passes more or less freely into the tympanum during respiration, and the patient is conscious of increased resonance of his own voice (autophony). This latter phenomenon is most often observed in debilitated patients; not only their own voices, but other sounds produced near them, appear louder than natural, so that the sensation becomes very disagreeable. Dr. Sexton explains autophony as due to the fact that vocal sounds, instead of being heard after passing through the mouth and external air to the drum of the ear, gain access to the auditory nerve by traversing the tissues between the mouth and ear in a more or less direct line, and are thus heard *false* in comparison with normal hearing. In some cases the increased resonance is no longer perceived when the patient either bends the head forwards or lies down.

As a result of free communication between the tympanum and the outer air, the respiratory movements are sometimes accompanied by corresponding vibrations of the membrana tympani, especially if the membrana propria is absent as a result of previous inflammation, and only the mucous and epithelial layers remain. During inspiration the membrane bulges outwards, and is withdrawn during expiration. Associated movements of an opposite character have been occasionally observed. When decided patency of the tube exists, the surgeon may hear a blowing sound during ordinary breathing.

Ulceration of the Eustachian Tube.—This process occurs at the pharyngeal orifice in connection with diphtheria, small-pox, tuberculosis, and syphilis. In *diphtheria* of the naso-pharynx the pharyngeal orifice is prone to be attacked; a tubular false membrane or a semi-solid plug may form in the tube, and be subsequently cast off, leaving an ulcerated surface. Necrosis and gangrene of the cartilaginous portion of the tube have been observed in rare cases. In *small-pox* the tube is frequently involved; the cartilaginous portion is filled with tenacious mucus, sometimes mixed with blood. The lymphoid elements of the mucous membrane are considerably increased, and infiltrated with blood. Superficial ulcers likewise form, but generally heal without cicatrisation, and do not cause adhesion of the lips of the orifice.

---

* *Lehrbuch der Ohrenheilkunde.* III. Aufl. S. 197.

Tuberculous ulcers of the naso-pharynx may extend to the tissues bounding the pharyngeal orifice and lead to their destruction. In like manner tuberculosis of the tympanum may extend to the osseous portion of the tube. Prof. Habermann states that he has several times seen tuberculous processes in the Eustachian tube. In one case the cartilaginous portion contained deposits of miliary tubercle with characteristic bacilli; and similar deposits, some partially caseous, were found in neighbouring portions of the pharynx.

Primary syphilitic affections of the pharyngeal orifice are occasionally observed, the infection having been conveyed by the Eustachian catheter. Secondary and tertiary manifestations of syphilis are not uncommon; they take the form of condylomata, gummatous deposits, and ulceration. The cicatrisation of syphilitic ulcers sometimes leads to occlusion of the tube. Exostoses in the osseous portion are occasional results of syphilis.

Treatment.—In the treatment of constriction of the Eustachian tube, the condition of the naso-pharynx is the first point to be attended to. Chronic hyperæmia, thickening and excessive secretion must be dealt with by the application of the remedies already described. It sometimes happens that the pharyngeal orifice is occluded by crusts or plugs of inspissated mucus, and that after these are removed the function of the part is completely restored.

Constrictions of the tube, the result of swelling of the mucous membrane, should be treated by means of the air-douche, the effect of which is to remove secretion and to distend the cartilaginous portion of the canal. Should the air-douche fail to afford relief, injections of a warm solution of iodide of potassium (see page 328) should be made into the tube, and iodide of potassium given internally. An alkaline lotion should be sprayed through the nostrils into the naso-pharynx several times a day. The amount of success will depend upon the character of the stricture.

Abnormal patency of the tube may sometimes be relieved by astringent injections (such as sulphate of zinc, gr. i.—ij. to ℥j.). Gargles containing common salt may also be tried. V. Tröltsch's method of gargling the throat (see page 299) is likely to prove serviceable. In cases presumably due to pathological conditions of the muscles of the tube, the faradic current should be used. One electrode is placed within the tube and the other on the side of the neck. In ulceration affecting the pharyngeal orifice, the treatment must be adapted to the nature of the case. In tuberculous and syphilitic subjects, constitutional remedies are always necessary.

CHAPTER XXIII.

DISEASES OF THE TYMPANIC CAVITY—INTRODUCTION.

DISEASES of the tympanum constitute by far the largest class of aural affections. Statistics* show that about two-thirds of these disorders (66·9 per cent.) occur in the middle ear. *Men* are more liable to suffer than *women*, the proportion per cent. being 58·4 : 41·6. With regard to *age*, we find that children constitute about one-fourth, viz., 25·2 per cent. of the total number of patients.

Their numerical preponderance would amply suffice to denote the importance of diseases of the middle ear; but their liability to affect the hearing-power to a very serious extent, and to produce complications of an exceedingly grave character, constitutes a still greater claim upon the attention of surgeons. The relations of the tympanum to the contents of the cranium are of a very intimate character; it is not to be wondered at that diseased conditions of the tympanic cavity are attended with more or less risk to the brain, to its membranes, and blood-vessels. Serious constitutional disorder may likewise result from intra-tympanic disease.

The most common middle-ear affections are caused by catarrhal and inflammatory processes involving primarily the mucous membrane, and often confined thereto, though liable, in many cases, to spread to adjacent structures. In typical cases, these affections may be divided into three classes, the classification being based upon the anatomical changes and the clinical symptoms. The first class includes catarrh (acute and chronic) of the middle ear; the second, suppurative inflammation, likewise subdivided into two sub-classes; while the so-called "dry" or "adhesive" catarrh, or sclerosis of the middle ear, has so many special characteristics, that it must be placed in a separate category. Before giving particular descriptions of the various forms, it seems desirable to take a general review of the catarrhal and inflammatory affections of the middle ear.

---

* See papers by Bürkner and Bezold in *Arch. f. Ohrenheilkunde*, xx. 81; xxi. 240; and xxv. 211; and Bezold's *Ueberschau über den gegenwärtigen Stand der Ohrenheilkunde*, 1895.

Morbid Appearances.—**Catarrh** of the lining membrane of the tympanum is characterised by hyperæmia and swelling, due to enlargement of vessels, serous transudation, and cellular infiltration of the connective tissue. In addition to these changes there is more or less abundant exudation of a mucous, colloid or serous character on the surface of the membrane. In the earliest stage, the secretion consists of mucus, formed in the lining epithelial cells, and in the cells of the mucous glands. In a later stage, the mucous secretion is checked, and replaced by a more or less abundant serous exudation.

Suppurative Inflammation involves the deeper periosteal layers of the lining membrane; besides the hyperæmia and the serous and cellular infiltration, the exudation contains a considerable percentage of white blood-cells, and though new formation occurs, the processes decidedly tend to the destruction of tissue. Caries and necrosis are frequent consequences of acute and chronic suppurative inflammation within the tympanum. In some cases, and notably in tuberculous patients, there is abundant purulent exudation, but the other signs of inflammation are either very slight or altogether wanting.

"Dry" or "Adhesive" Catarrh is accompanied by changes of which only the final stages are well known. In some cases they are preceded by the symptoms of catarrh; in others no such history is obtainable. When the condition is fully developed, the mucous membrane becomes thickened and rigid, various parts of the sound-conducting apparatus lose their elasticity, and the movements of the ossicles become impaired or altogether abolished.

The **Symptoms** are in some degree a guide to the nature of the case. In catarrh of the middle ear, the pain is most often slight or moderate; and, if severe, it is generally intermittent. In children, the fever and constitutional disturbance are usually prominent symptoms. So long as the process is purely catarrhal, it does not involve the middle and external layers of the tympanic membrane. They may, however, even in the early stage, be somewhat hyperæmic, and the membrane itself is apt to assume a diffuse bright red colour, by reflection from the reddened mucous membrane covering the promontory. But little change occurs in the thickness and translucency of the membrane, so that in purely serous exudations the level of the fluid can be easily distinguished. The normal curves of the membrane may, however, undergo decided alterations. Perforation is by no means a necessary result.

Acute Purulent Inflammation of the middle ear often sets in with one or more distinct rigors; the pain is severe and continuous; there is much constitutional disorder and often high fever; perforation of the tympanic membrane is the almost invariable result, and the inflammatory process may extend to the labyrinth. The acute disease often passes into a chronic form.

"**Adhesive**" or "**Dry**" **Catarrh** of the middle ear comes on insidiously; tinnitus is often the first symptom noticed by the patient. After a time, perhaps not until the hearing-power has been decidedly impaired, the patient is conscious of deafness, easily discoverable on applying the usual tests. In "dry" catarrh, accompanied by sclerosis, the membrana tympani is comparatively normal. The appearance through the membrane of a dull-red or orange-coloured spot, corresponding to the promontory, is characteristic of this form of disease.

The brief sketch just given of the various inflammatory processes which take place in the middle ear is sufficient to show that great differences exist, both in the structural changes and in the symptoms to which they give rise. Their course also varies, being sometimes acute or subacute, and sometimes chronic; the termination in some cases is favourable; in others, it is just the opposite; while in a very numerous class, more or less permanent alteration of structure is associated with a corresponding impairment of function. There is no foundation for the view that the various forms of middle-ear inflammation are stages of one and the same morbid process. Some of these forms may pass into others, *e.g.*, a catarrhal process may be succeeded by purulent inflammation, and this in time may subside, and the secretion may become serous in character. A superficial form of inflammation may be so far changed as to invade the deeper structures, and this alteration is apt to occur when the process continues for any length of time. Clinical experience, however, shows that certain forms of inflammation of the middle ear exhibit certain typical peculiarities, which they often retain throughout their course.

Besides those already mentioned, other forms of inflammation occur in the tympanum. In one of these, the exudation contains fibrinogenic and fibrinoplastic elements, and undergoes coagulation. Thus the surface of the mucous membrane becomes coated with an adherent film or croupous false membrane. In another form, the membrane is diphtheritic in character, and the deeper layers are especially involved. In a third variety, termed "desquamative" inflammation, epithelial cells are formed and shed in vast numbers, and are mingled with the secretion. The cylindrical cells are replaced by others having a tesselated arrangement and form.

Impairment of Function, a common symptom of these affections of the middle ear, is caused by anatomical and physical changes in the sound-conducting apparatus. The most important of these changes are those which interfere with the movements of the ossicles and of the structures closing the fenestræ. When such morbid conditions tend to subside or can be removed by appropriate treatment, as in acute catarrh and in many cases of acute purulent inflammation, restoration of function is the ordinary result. In the chronic forms of these diseases, much improvement can often be effected; whereas in chronic adhesive catarrh, the hearing-power usually becomes less and less as time goes on, and the results of treatment are often very unsatisfactory.

The fact that the mastoid cells and the Eustachian tubes frequently participate in tympanic inflammations is one of great importance. The same morbid process, however, does not always prevail in these parts at the same time. Thus the disease in the tympanum may be of a purulent character, while the process in the mastoid cells may be catarrhal in type. Chronic purulent inflammation of the tympanum is not infrequently followed by acute disease in the mastoid cells.

CHAPTER XXIV.

ACUTE CATARRH OF THE MIDDLE EAR.

Frequency and Causes of the Disease—Affections of the Throat—Part Played by Micro-organisms—Channels of Access—Morbid Appearances—Subjective Symptoms—Impairment of Hearing—Subjective Sensations—Autophony—Increased Temperature—Objective Symptoms—Appearance of the Meatus and Membrane—Effects of the Air-Douche—Auscultation and Sounds Heard—Diagnosis—Prognosis—Treatment—Attention to the Naso-Pharynx—Relief of Pain—The Air-Douche—The Operation of Paracentesis—Spontaneous Perforation and its Treatment—Treatment of Adenoid Growths and of Enlarged Tonsils, when Present.

ACUTE catarrh of the middle ear is of somewhat frequent occurrence; thirteen per cent. of aural diseases are of this nature. Adults are more liable to suffer than children, and males are more often affected than females. In rather more than half the number of cases both ears are affected; when the complaint is unilateral, it occurs as frequently in the right ear as in the left.

Causes.—Catarrh of the middle ear is often attributed to exposure to cold; the complaint is more common in wet and cold weather and in damp localities, than under opposite conditions. The liability of children to suffer from this disorder is due to several causes. In early life, the lips of the pharyngeal orifice of the Eustachian tube are but slightly developed, and closure is very apt to result when the pharynx is affected with catarrh. In patients of all ages, catarrh of the middle ear is most often due to disorders of the naso-pharynx. Thus it may come on during an ordinary cold in the head, or an attack of pharyngitis; or it may complicate chronic affections of the naso-pharynx, such as rhinitis and chronic pharyngitis, hypertrophy of the tonsils, and adenoid growths. All febrile and other disorders which are apt to be complicated by nasal and pharyngeal affections may be regarded as predisposing causes of middle-ear catarrh. Among such diseases, scarlet fever, measles, diphtheria, typhoid fever, influenza, and syphilis are those in which the tympanum is especially liable to suffer; but the resulting inflammation is more often of the suppurative kind. Tuberculosis is likewise a predisposing cause of catarrh of the middle ear.

The affection of the throat which is most often associated with middle-ear catarrh in children and young adults is adenoid growths. They form a constant source of irritation to the mucous membrane; moreover, they may press upon the mouths of the Eustachian tubes and impede the circulation of blood and the escape of the secretion. Gruber suggests that they may also act in another way, viz.:—by preventing the action of those muscles of the tubes which are contained in the soft palate, and thus interfering with the ventilation of the tympana. In adults, obstructions in the nostrils, narrowing and occlusion of the nasal passages, and enlargement of the inferior turbinated body, are often associated with middle-ear catarrh and require careful treatment. When these conditions occur in children, they are often the result of post-nasal growths, and disappear when the growths have been removed.

Adenoid growths in the naso-pharynx have been already described in the chapter on Throat Affections connected with the Ear. It is sufficient to repeat that these growths vary in size, and occupy more or less of the naso-pharyngeal space. They may completely occlude the posterior nares, obstruct the orifices of the tubes, and cause the soft palate to protrude forwards into the mouth. When these growths are present, slight causes are often sufficient to excite attacks of pharyngeal catarrh, with extension to the tympanum as a possible result.

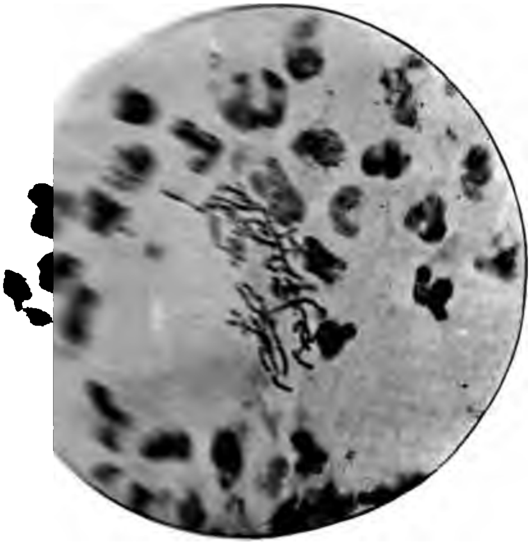
In the cases above described, the propagation of catarrh from the naso-pharynx to the tympanum takes place through the Eustachian tube; but when the orifice of the latter is occluded, the tympanum is affected in another way. The air contained in the cavity is to some extent absorbed by the blood-vessels; rarefaction takes place, and causes an indrawn condition of the membrane, hyperæmia and swelling of the mucous lining, and effusion of fluid (*hydrops e vacuo*).

The part played by **micro-organisms** in causing and maintaining catarrh and inflammation of the middle ear cannot as yet be positively estimated. It may, however, be regarded as certain that many of these organisms are closely connected with the development of the processes referred to. The following paragraphs contain a summary of the most recent investigations on this subject.

The micro-organisms most often found in tympanic exudations are the *diplococcus pneumoniæ* and the *streptococcus pyogenes*. Next in frequency come the *staphylococcus pyogenes albus* and *aureus*, and the *bacillus tuberculosis;* less commonly, the *pneumobacillus* of Friedländer, the *bacillus pyocyaneus*, the *staphylococcus cereus albus*, and the *micrococcus tetragenus*. It is doubtful whether the two last are pathogenic in character. Several kinds of micro-organisms are often present at the same time; it is therefore difficult to assign to any one of them a principal share in the causation of inflammation. The late Dr. Kanthack's* researches show that in cases of acute otitis media, *pure* cultivations of the *diplococcus pneumoniæ* are rarely obtainable; in most cases the *diplococcus* is associated with the *staphylococcus*, and that even where the membrana tympani is entire, other non-pathogenic organisms (bacilli) are found. "We need not wonder that saprophytes and other bacilli find their way into the middle ear, when we consider that the latter communicates with the naso-pharynx, and thus with the air; and again, that the *bacillus saprogenes I.* is often found in normal saliva." It is worthy of note that similar organisms were found in seven other cases in which exudation was present in the tympanum, without evidence of any decided symptoms of inflammation. In cases of chronic otorrhœa, the *diplococcus pneumoniæ* was not discovered. It would, moreover, seem that various kinds of micro-organisms may occur in succession, and that inflammatory processes about to subside may be rekindled by the advent of other forms of bacteria. Thus Zaufal's investigations show that a pathogenic micro-organism, exciting otitis media, may be succeeded by another kind of organism having the same properties. The *diplococcus pneumoniæ* may be succeeded by

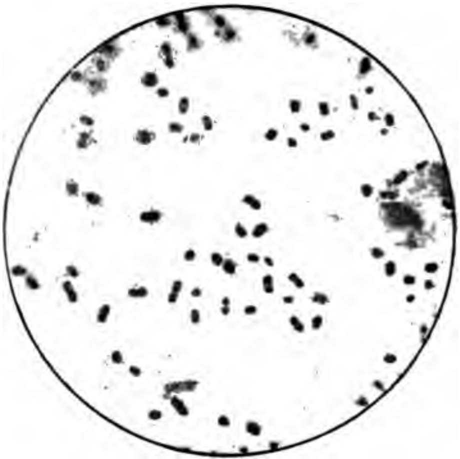
---

* *Archives of Otology*, vol. xix. p. 29.

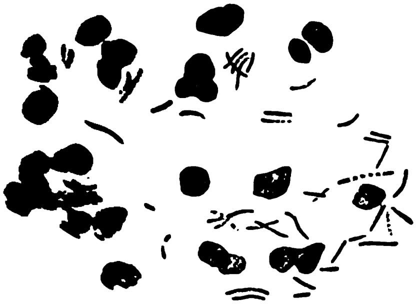


[illegible]OCCUS PYOGENES.

[illegible]



STAPHYLOCOCCUS PYOGENES AUREUS.



TUBERCLE BACILLUS.

FIG. 93.

[illegible] taken from [illegible]'s *Micro-Organisms and Disease.*

the *staphylococcus pyogenes albus*. Such a change is believed to be the main cause of the chronic character of suppuration of the middle ear. The original excitant perishes, but has left the soil prepared for other germs. Zaufal's investigations have also shown that in rabbits the normal tympanum is not free from germs, and that various micro-organisms are abundant in the naso-pharynx.

The difficulties in determining the micro-organisms specially concerned in the production of otitis media are very considerable. Moreover, the organisms of certain infectious diseases, prone to implicate the organ of hearing, have not as yet been clearly distinguished. We have no positive information as to the excitants of measles and of scarlatina, in both of which aural complications are decidedly frequent. In fatal cases of diphtheria, implicating the tympanum, the peculiar bacillus can rarely be demonstrated in the ear. In a case of scarlatina, Dr. Kurth,* of Berlin, discovered a streptococcus (*S. conglomeratus*) which he believed to be peculiar to the disease. Some time afterwards, precisely similar organisms were found in a case of acute middle-ear inflammation, without any history of scarlatina.

As a general rule, it is impossible to draw any conclusions as to the degree or course of the inflammatory process from the kind of micro-organism contained in the exudation. One and the same form may be associated with very different degrees of the inflammatory process. No doubt the virulence of micro-organisms varies greatly from time to time, and great differences exist in the conditions which influence their development. The actual presence of bacteria is not enough to excite inflammation; other circumstances, favourable to the development and multiplication of the organisms, must likewise exist.

Channels of Access.—There are several routes by which pathogenic micro-organisms may gain access to the tympanum. As a general rule, the Eustachian tube is the channel through which inflammation is propagated. It is possible that pathogenic bacteria may pass through the tube during vomiting, along with a minute quantity of the contents of the stomach, and that any that may remain in the throat or nose may be forced into the tube during violent expiratory efforts. There is a second route by which micro-organisms may pass into the tympanum, viz., through the blood-vessels. In many cases of middle-ear disease connected with infectious disorders, the excitants of inflammation may take this course, but actual demonstration has not yet been afforded. It is easy to understand that when the tympanic membrane is perforated, pathogenic and non-pathogenic bacteria may pass into the tympanum and undergo further development. It far less commonly happens that inflammatory processes extend to the tympanum from neighbouring parts, such as the external meatus, the labyrinth, and the base of the skull.

---

* Schwartze, *Handbuch der Ohrenheilkunde*, Bd. I., S. 549.

Morbid Appearances.—The tympanum contains more or less serous exudation mixed with mucus, the proportion of these constituents varying in different cases. Besides mucus, the exudation contains a large number of epithelial cells, much swollen and otherwise altered; pus corpuscles are likewise often present. The mucus is formed from the goblet cells of the epithelium; the mucous membrane itself contains but very few glands. Many of the epithelial cells are in a state of complete mucoid degeneration. The mucous membrane itself is reddened and swollen, either on distinct spots or throughout its extent. The tympanic membrane is often transparent and presents an unusually bright appearance, and permits the level of the exudation to be seen through it; but when the inflammatory processes are severe, its tissues become infiltrated and opaque, and the lustre of its surface is diminished or altogether lost. An excessive amount of exudation may cause the membrane to bulge into the meatus, but as previously mentioned an indrawn condition of the membrane is often present. On microscopical examination, the epithelial layer is found to be thick and swollen, the vessels are enlarged and distended with blood, and superficial patches of infiltration are noticed. Leucocytes are mingled with the secretion in the neighbourhood of these patches. Perforation of the membrane rarely occurs, notwithstanding the pressure of the exudation; but when the membrane is severely implicated its tissues may give way, and the fluid will then escape into the meatus. In the majority of cases of acute catarrh, absorption takes place, and the process completely subsides. The symptoms, however, are liable to return, and the complaint not infrequently assumes a chronic form, in which case fluid may remain in the tympanum for weeks and even months. When this stage has been reached, slight causes will often bring on acute attacks.

In tuberculous children an exudation, at first serous or mucous, is liable to become purulent; perforation of the membrane is then likely to ensue.

Subjective Symptoms.—In the majority of cases the first symptom of acute middle-ear catarrh is a feeling of pressure and fulness in the ear; this sensation rapidly becomes more and more marked. The patient, however, notices that the feeling passes off at times, particularly after swallowing and blowing the nose. The improvement is due to the opening of the Eustachian tube, and its advent is often accompanied by a crackling noise. Pain is soon experienced, but this symptom varies greatly in character. Sometimes it is very slight; in other cases its severity is described as almost unbearable. It is generally of a pricking, boring character, not confined to the ear, but spreading over the side of the head. The pain, which may be continuous or intermittent, is mainly due to increased tension of the membrana tympani, as a result of the exudation within the cavity. It is aggravated by such movements as tend to shake the membrane, and notably by coughing, sneezing, and blowing the nose, and by movements of the jaw. It sometimes extends to the mastoid region. The pain of catarrhal middle-ear inflammation is sometimes very severe in children, and exacerbations are very apt to occur at night. As a general rule, the pain subsides after a few days; it may recur, but with diminished severity. In some cases the affection runs such a mild course that fluid may collect in the tympanum, and escape by perforating a previously healthy tympanic membrane without pain being produced.

The hearing-power is more or less affected, but if the catarrh be unilateral the loss may not be noticed by the patient. In some cases impairment of hearing is present from the commencement of the attack; in others, it comes on later. It is due either to the condition of the sound-conducting apparatus, or to implication of the labyrinth. In the former case, conduction is impaired by the swelling of the mucous lining, and subsequently by the thickening of the tympanic membrane, impeded movement of the ossicles, and accumulation of secretion. The deafness varies greatly in degree, being sometimes very slight, and sometimes almost complete. When the fenestræ are covered up by exudation, the hearing is certain to be much impaired.

Subjective auditory sensations are due to the same causes as produce the deafness, and are very variable in character. Adult patients are seldom free from them, but it rarely happens that children mention them. It may be that in young subjects the intra-labyrinthine tension is less liable to vary.

Autophony is another symptom which is often noticed. The patient complains of the loudness of his own voice as heard in the affected ear. Not only the voice, but sounds produced on touching the head annoy by their loudness; brushing and combing the hair are disagreeable to the patient. This altered sensation is due to closure of the Eustachian tube. Double hearing and modifications of various sounds are occasional symptoms.

Increase of temperature is frequently present, especially in children. The fever may be either continuous or intermittent, and may not altogether subside until the exudation has become absorbed. More serious symptoms, such as giddiness, violent headache, insensibility, and epileptiform attacks are far less common than in acute purulent inflammation, but they may occur during the progress of catarrh of the tympanum. Giddiness is due to pressure upon the structures of the labyrinth, and it may also be caused by extension of the hyperæmia of the tympanic vessels, through the petro-squamous fissure to the meninges. There is another possible cause, viz., transference of the irritation of the sensory nerves to the centres which regulate the equilibrium. Symptoms of facial paralysis are occasionally noticed during the course of middle-ear catarrh; they are due to escape of effusion into the Fallopian canal through small apertures in the posterior wall of the tympanum, or to pressure consequent on an extension of the catarrhal processes. Other symptoms, rarely observed, are due to implication of the chorda tympani nerve, and take the form of increased secretion of saliva and perversions of taste. Neuralgia of some branches of the fifth nerve is sometimes complained of.

Objective Symptoms.—In the examination of a patient the surgeon's attention should be first directed to the state of the nose and naso-pharynx, for it is in these parts, and especially in the latter, that lesions are often found to which catarrh of the tympanum is due, and which therefore require treatment. Hence posterior rhinoscopy should never be neglected, and the state of the naso-pharynx should be carefully noted. When the aural catarrh is connected with some constitutional disorder, such as tuberculosis or syphilis, the glands about the ear will generally be found swollen.

The appearance of the meatus and membrane varies in different cases and in different stages of the complaint. Sometimes the meatus appears normal, but more often the integument lining the osseous portion is hyperæmic and swollen. The varied conditions which are found with exudation into the tympanum are usually dependent upon the stage to which the catarrhal changes have progressed, and on the part of the middle ear which is affected. In most cases in which the membrane is transparent and depressed the patient does not experience pain, and is merely conscious that his "cold" has made him deaf and caused a feeling of fulness in the ear. In such a case the naso-pharyngeal catarrh has prevented the entrance of air into the tympanum, and, in consequence, a vacuum has been formed, and serous exudation may have resulted; but the catarrhal changes have not involved the tympanum, or only to a slight degree. On the other hand, when the membrane is opaque or bulges into the meatus, it is an indication that the tympanum has been invaded.

On examining the membrane when the tympanum has been affected, the earliest visible changes are diminution of lustre and increased concavity. The surface is usually dull, like glass that has been breathed upon; the cone of light is less distinct than usual; the short process projects, and the anterior and posterior folds, but especially the latter, become more tense and prominent. The vessels which are contiguous to the handle of the malleus are considerably enlarged, and tortuous vessels extend from the periphery towards the centre. Sometimes the membrane has a more decided polish than normally belongs to it; its colour, especially at its lower and anterior part, is darker than usual, or perhaps has a reddish tinge communicated to it by the lining membrane of the tympanum. The handle of the malleus remains visible, unless obscured by the congested vessels, or covered by the posterior fold. The colour of the tympanic membrane soon becomes changed; the red tinge disappears, and gives place to a yellowish-white or yellowish-green hue. The change is owing in part to the subsidence of the congestion, but mainly to the exudation in the cavity of the tympanum. When the secretion is copious, and the membrane is inflamed, it may bulge out towards the meatus; otherwise it may be in its normal position, or even depressed. The latter condition is the result of atmospheric pressure acting on it after the air which was in the tympanum has been almost or entirely absorbed, and more cannot enter on account of the swollen condition of the Eustachian tube. The colour of the membrane, as above described, is very marked in its lower segment. Sometimes yellowish specks are visible; these are caused by tiny patches of exudation adherent to the internal surface of the membrane. As shown in Fig. 96, the upper surface of the exudation is marked by a dark line a millimetre or less in thickness, caused by the refraction of light from its surface. This dark line is seen in a variety of forms and positions according to the amount of exudation present. When only a small quantity exists, the line is usually clearly visible as in Fig. 96, and is generally more or less curved with the concavity upwards. In other cases when the highest point of the exudation is at the umbo, or above it, the surface may slope towards the periphery on both sides of the handle, causing two curved lines. Sometimes the line is more or less vertical, and only one or two millimetres in length; this appearance being probably caused by the refraction of light from the edge of the fluid in contact with a bubble, although the latter is invisible. When the quantity of the exudation is large, the line may be quite at the upper part of the membrane; and, when the tympanum is full, no line may be visible. It less frequently happens that without any decided change in the lower part of the membrane, its surface appears to be crossed by one or two very fine lines, resembling hairs. The existence of a dark line

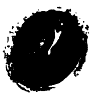


FIG. 94.

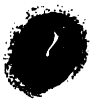


FIG. 95.

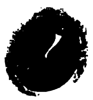


FIG. 96.

Fig. 94.—The right ear of a gentleman, aged 56, showing the tympanum filled with fluid, with the exception of the space occupied by a bubble in the upper anterior segment, and another in the posterior segment.

Fig. 95 shows the appearance of the same ear after a little air had been injected, and before the bubbles had time to rise to the top of the fluid and coalesce.

Fig. 96.—A small quantity of fluid in the right tympanum.

is a certain indication of the presence of exudation, but its position, direction, and length vary so much that no form is typical. When the exudation is visible, movement of the head forwards or backwards will cause an alteration in the level of the fluid, and consequently in the position of the dark line, and also in the colour of portions of the membrane.

Effects produced by the Injection of Air.—The exudation, as visible through the membrana tympani, presents a different appearance when air is introduced by means of a Politzer's bag, or through a catheter (Fig. 95). The surface line is no longer visible, and the yellow coloration is succeeded by a number of small dark circles, which may move about and then disappear. These are air-bubbles, produced by the inflation. At the same time the hearing-power is decidedly improved, unless the tympanic cavity be quite filled with exudation. As tested by the watch, bone-conduction, which may have been much impaired by the exudation, is likewise restored after air has been injected. The tuning-fork test, when the affection is unilateral, gives the following results—increased perception on the affected side with Weber's experiment, and "negative" with Rinne's test.

On auscultation whilst air is being injected, rattling sounds or râles are generally heard. These seem to originate near the ear of the observer; their character varies according to the quantity and quality of the secretion. When the latter is thin and serous, the sounds may be described as "crackling"; when it is mucous and viscid, "bubbling" sounds are heard. No sound is produced when the tympanum is completely filled up with exudation, or when the Eustachian tube is impermeable to air. Even when exudation is present, no bubbling sound will be caused by the entrance of air, unless the fluid be thrown into agitation. This result is also noticed when the exudation is small in quantity, and just covers the floor of the tympanic cavity. It must be remembered that several injections of air may be required before any sound is produced; the first attempts may only suffice to overcome the resistance of the walls of the Eustachian tube. The sound is likely to be of a very indefinite character when the tympanum contains a little tenacious secretion; in such cases, a distinct pop may sometimes be heard when air is injected.

The **Diagnosis** of acute middle-ear catarrh is for the most part easily made; the objective symptoms are sufficiently characteristic. In doubtful cases, the results following upon the injection of air will establish the diagnosis.

Prognosis.—This is favourable in the majority of recent cases, provided that suitable treatment be adopted. When the catarrh has lasted for some time, the prospect is less favourable; adhesions may have formed, and the changes in the mucous membrane may be but slightly influenced by treatment. The following conditions may be regarded as unfavourable: a decided tendency towards relapse and chronic stages; the supervention of purulent inflammation; complications in the labyrinth; syphilis; tuberculosis, anæmia, and exhausting diseases in general.

The tendency towards relapse is apt to be very marked in cases of chronic disease of the nose and pharynx. The results of inflation of the middle ear greatly influence the prognosis. If hearing-power be considerably improved when this method is employed, the prospect is decidedly good; if there be little or no alteration, the chances of recovery are proportionately doubtful. When there are evidences of labyrinthine mischief, little, if any, improvement can be expected.

The duration of the disease in ordinary cases is from two to six weeks, although the exudation may be removed in one or more days. Pain is usually the first symptom to subside; later on the hearing-power is recovered, and tinnitus ceases to be troublesome. This last symptom may, however, continue for some time after all other signs of the disease have disappeared. The habits of the patient, especially as regards alcohol, and the general state of health, must be borne in mind in estimating the chances of recovery. In all cases of acute middle-ear catarrh, the patient should be made aware of the possibility of recurrence, and of the supervention of a chronic stage.

Treatment.—In the treatment of acute middle-ear catarrh there are two principal objects to be kept in view, viz., to cure the local affection, or to diminish the severity of the process; and secondly, to prevent relapses. Confinement to the house is always desirable, and should be prescribed even for mild cases. When there are any signs of fever, the patient should be kept in bed. All causes tending to produce congestion of the head must be carefully avoided; the diet should be of a light, non-stimulating character, and alcoholic fluids and tobacco should be forbidden. The state of the bowels requires attention; purgatives, and especially salines, are generally indicated. For the direct treatment of the catarrh a careful examination of the naso-pharynx should be made, inasmuch as the starting-point of the disease is often to be found in that part. The treatment of the antecedent disorder has been described in a previous chapter, which dealt with the affections of that region.

Treatment must next be adopted for the relief of the pain in the ear. For this purpose two or three, or even more, leeches may be applied in front of the tragus and in the sulcus behind the lobule immediately beneath the meatus. Cold compresses may be placed over the auricle and side of the neck. Leiter's apparatus is convenient for the application of cold. Various anodyne solutions are sometimes serviceable. Those most likely to prove efficacious are a 20 per cent. solution of hydrochlorate of cocaine, a solution of acetate or hydrochlorate of morphia—two grains to one drachm, or a 2—10 per cent. solution of atropin and cocaine, four or five drops of which may be used at a time. The effects should be carefully noticed. (See page 154 for method of warming drops.) Politzer* recommends a mixture of acetate of morphine and olive oil (1 to 50) to be warmed and introduced into the meatus on cotton-wool, or a mixture of olive oil and chloroform (equal parts) to be dropped on a piece of wadding and applied over the ear. Glycerine of carbolic acid (introduced into the meatus on cotton-wool) will also tend to relieve the pain. A blister† or mustard plaster, or if the symptoms are only slight, the liniment, or equal parts of the liniment and tincture of iodine, may be applied to the mastoid process. Warm poultices, warm fomentation, steaming the ear, etc., must never be employed; they are liable to cause softening and disintegration of the membrana tympani. In the case of children the pain may be relieved by expiring into the ear.

The Introduction of Air.—The most important part of the local treatment consists in the introduction of air, the effects of which are to modify the condition of the tympanum by restoring the permeability of the Eustachian tube, relieving the pressure on the ossicles and membrane, scattering accumulated secretion and promoting its absorption. The prevention of adhesions between various structures of the tympanum is another result to be desired. These objects may be attained by Politzer's method, or by means of the Eustachian catheter if the former method fail. When pain is a prominent symptom, and the tympanic membrane is reddened and swollen, the air-douche should be employed with great caution, lest the membrane should be ruptured or the symptoms of inflammation aggravated rather than improved.

---

* *Lehrbuch der Ohrenheilkunde*, Aufl. II. S. 269.

† The blistering fluid (Emp. Cantharidinis Liquid.) which has been used for many years at the Royal London Ophthalmic Hospital, is a very good preparation; and, in consequence of its greater consistence, is much less liable to run from the place to which it has been applied than the B.P. form. It is manufactured by T. & H. Smith & Co., 12, Worship Street, London, E.C.

When pain and other symptoms of inflammation of the middle ear are absent, the best treatment for the removal of the exudation from the tympanum, in addition to the more general treatment previously mentioned, is frequent injection of air by means of Politzer's method. The patient should be directed to inflate the ear about every hour, with the object not only of preventing a vacuum re-forming, but also keeping up intra-tympanic pressure, and thus favouring the re-absorption of the fluid. When the exudation is in one ear only, the other may be stopped by a finger, or by pressing the tragus against the orifice of the meatus, but this precaution is not necessary if the membrane is healthy. The patient should be instructed to use only sufficient force to obtain the entrance of air into the tympanum, and not to repeat the process when successful more than two or three times on each occasion. In recent cases this treatment often removes the exudation entirely in the course of one or two days. When air cannot be forced into the middle ear by Politzer's method, a catheter must be used, and when the nostrils are sensitive, it is well previously to spray into them a 2 per cent. solution of cocaine. After the fluid has been absorbed, it is advisable for air to be injected daily for the next week or so in order to prevent it from re-collecting.

In the majority of cases unattended with acute symptoms, the introduction of air, aided by the other measures already described, will suffice to bring about complete recovery. When, however, the symptoms appear to be unaffected by treatment, it may become necessary to make an opening in the membrana tympani. The operation is always indicated when the exudation causes bulging of the membrane and when the tympanum is inflamed. Under the latter circumstances, neither Politzer's method nor the use of the catheter will prove efficacious; on the other hand, the injection of air into the ear will tend to aggravate the pain and inflammation. Moreover, not only treatment of this character, but even the act of blowing the nose somewhat violently may drive exudation from the tympanum into the mastoid cells, and thus cause an extension of the mischief. In these severe cases, the exudation is rarely absorbed; as a general rule, the membrane speedily becomes ruptured.

The Operation of Paracentesis.—A small lance-shaped knife is the best instrument for this purpose; it should be thoroughly disinfected by holding it for several minutes in boiling water or in absolute alcohol, and then drying it with sterilised cotton-wool. In order to provide for the escape of the secretion, it is desirable to make an incision rather more than the sixteenth of an inch in length, the best spot to select being in the inferior half of the membrane, between the umbo and the posterior inferior margin of the meatus. The incision into the membrane sometimes causes sharp pain, and some anæsthetic is therefore necessary. Cocaine is usually sufficient; a few drops of a warm 20 per cent. solution may be dropped into the ear, or the meatus may be filled with the same fluid. Before using the cocaine, however, the meatus should be thoroughly syringed out with a solution of perchloride of mercury ($\frac{1}{10}$ per cent.). It should then be dried with cotton-wool, after which the cocaine solution may be introduced and allowed to remain for about five minutes. If the cocaine be insufficient, chloroform must be administered. A good light must be thrown upon the membrane, and the patient's head carefully held while the incision is made.

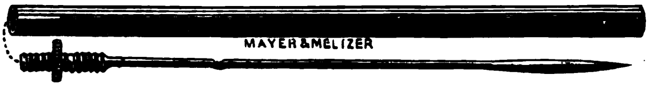


FIG. 97.

A MYRINGOTOME.

The incision is followed by the discharge of muco-serous secretion, sometimes in considerable quantity. Its escape may require to be expedited by air-propulsion; for this purpose a

Politzer's inflation may be given, or, what is better, air injected through a catheter. A piece of absorbent wool should be previously placed against the opening in the membrane to take up all the fluid which escapes. The advantages of a catheter are that the force of the air injected can be regulated according to the consistence of the fluid, and the sound produced by the air indicates whether or not all the secretion has been removed. Whilst fluid remains in the tympanum, a bubbling sound will be heard through the auscultation tube whenever air is injected; but as soon as the cavity is emptied, only a blowing sound will be perceived.

As a general rule, scarcely a drop of blood escapes after the puncture, unless there be considerable hyperæmia of the membrane. In a few cases, the operation has been attended with very considerable hæmorrhage. Five instances* have been recorded in which the knife passed through the floor of the tympanum into the commencement of the internal jugular vein. The hæmorrhage was arrested by a tampon of iodoform gauze. With ordinary precautions such an accident could not occur. The membrane should, of course, be very carefully inspected before paracentesis; in some cases, a blue discoloration can be detected close to the lower periphery. Hæmorrhage, less in quantity, may be caused by perforation of veins accompanying Jacobson's nerve.

When the operation is completed, the parts should be carefully dried with carbolised cotton-wool, and a plug should be retained in the meatus. The patient must be kept in bed, or at rest in his room, until the wound in the membrane has healed. Air should be injected several times daily in order to prevent a too rapid closure of the opening and to remove secretion from the cavity. The wound generally heals in three or four days, but it may do so in a few hours. Injections of air should be continued for some time afterwards, and until the hearing-power is restored. Should the exudation continue after the wound has healed, it will be necessary to make another opening. When this occurs, the opening should again be made in the position of the former one, in order to prevent unnecessary injury to the membrane.

In a large majority of cases, paracentesis of the tympanic membrane does not give rise to any inflammatory symptoms; but occasionally the operation is followed by evidences of acute purulent otitis. So undesirable a result has caused the operation to be regarded with disfavour by some authorities; but there can be no doubt as to its beneficial effects as a general rule. The possibility of aggravating the condition should, however, be borne in mind, and should emphasise the necessity of adopting antiseptic and other precautions.

---

* *Journal of Laryngology*, April, 1895, p. 309; see also *Arch. f. Ohrenheilkunde*, xxix. S. 234 and xxx. S. 183.

Spontaneous Perforation of the Membrane.—In some cases of acute catarrh of the tympanum, rupture of the membrane occurs spontaneously, and the surgeon, when first consulted, finds that there is a muco-purulent or purulent discharge from the ear. When this is the case, the pain and sensation of fulness will have greatly diminished, but the deafness and the noises in the ear may have become more marked, owing to increase of exudation, and secondary inflammation of the membrane. In such cases, after removing the discharge by syringing, and drying the meatus with cotton-wool, the membrane may be seen to be much reddened, so that the parts usually observable, such as the handle and short process of the malleus, can no longer be made out. The perforation appears as a yellowish-grey spot, pulsating simultaneously with the pulse at the wrist. This phenomenon is due to the fact that the impulse of the pulse-wave in the dilated vessels of the hyperæmic tissue of the tympanum and membrane, or in the internal carotid, is transferred to the layer of fluid covering these parts, and when they are illuminated the movement becomes manifest.

When a discharge from the ear has become established, as a result of spontaneous rupture of the membrane, the meatus must be cleansed once or twice daily by syringing with warm boric acid lotion. This drug, reduced to a fine powder, should be blown into the ear after the meatus has been thoroughly syringed out and dried with cotton-wool. When the discharge is purulent, it is sometimes advisable to syringe the ear with a solution of carbolic acid, 1 in 60 to 80, or of perchloride or biniodide of mercury, 1 in 1,000 to 2,000.

In exceptional cases, when the exudation is very tenacious, it may be advisable to syringe out the meatus with a warm solution of bicarbonate of soda or chloride of sodium (one or two per cent.), and to inject this fluid through the Eustachian catheter and wash out the tympanum. The tympanic mucous membrane, although very sensitive when in a normal condition, is not irritated by these injections when its tissue is relaxed and swollen after an attack of inflammation. On the other hand, in favourable cases, this treatment is followed by closure of the perforation and cessation of all symptoms in from ten to fourteen days.

When the opening in the membrane, whether spontaneous or made by the knife, proves too small, so that the exudation is still retained, it must be sufficiently enlarged. This operation will be followed by escape of secretion, restoration of the membrane to its normal position, and cessation of the pain in the ear and side of the head.

The external meatus often participates in the inflammation, becoming red, injected, and swollen, and this condition is apt to be maintained by the irritating discharge. The inflammation, however, subsides under the use of the remedies applied to the tympanum ; the insufflation of powdered boric acid generally has a good effect ; but should this irritate, the drug may be applied in the form of a saturated solution.

In children especially, adenoid growths are frequently present, and these growths are common causes of aural catarrh. If found, they must be removed in the manner described in the previous chapter (see page 308), as soon as convenient after the present affection has subsided.

Hypertrophy of the tonsils is another cause of middle-ear catarrh. The treatment consists in the removal of the tonsils (see page 288), or of a portion thereof, by means of the guillotine. If the patient will not submit to this treatment, an attempt may be made to diminish the size of the tonsils by the daily application of Tinct. Iodi on a camel-hair brush, and by the internal administration of the Syrupus Ferri Iodidi, or they may be destroyed with the electro-cautery.

CHAPTER XXV.

CHRONIC CATARRH OF THE MIDDLE EAR.

Chronic Catarrh of the Tympanum—Frequency and Forms, Catarrhal and Adhesive—Causes—Affections of the Eustachian Tube—Anatomical Appearances—Subjective Symptoms—Deafness, Noises in the Ear, Giddiness, Autophony, Paracusis, etc.—Objective Appearances—Condition of Membrana Tympani—Use of the Catheter and Air-Douche—Effects on Appearances—Perforation of the Membrane—Course—Diagnosis and Prognosis—Treatment—Attention to State of Naso-Pharynx—The Air-Douche, Politzer's Method, the Catheter—Chloride of Ammonium Vapour and Remedies in Fluid Form—The Use of Siegle's Speculum—Paracentesis and Plicotomy—General Treatment of Chronic Middle-Ear Catarrh.

Chronic Catarrh of the Tympanum is a decidedly common disease; about twenty per cent. of all cases of aural affections come under this heading. Adults form the majority of patients, and both sexes are equally liable to suffer. As a general rule, both ears are affected; when the complaint is unilateral, the left ear is more often attacked than the right.

A chronic stage often follows an acute attack of middle-ear catarrh; but in a considerable proportion of cases, there is no history of any definitely acute symptoms. Chronic catarrh appears in two principal forms: in one, the process is mainly catarrhal, *i.e.*, accompanied by more or less abundant secretion; in the second, the process is marked by hyperplasia of the mucous membrane, adhesions between various parts, and thickening and condensation of tissues. To this latter form, the term "dry catarrh" has been applied. There is no strict line of demarcation between these two types, inasmuch as the strictly catarrhal form may pass into the adhesive or sclerotic type of the disorder, and mixed forms often occur. Nevertheless, it seems consider separately the catarrhal form, and to d chapter to the description of the adhesive proces consequences.

Causes.—As already stated, a chronic stage m acute attack, or the symptoms may be graduall developed. In the latter class of cases they are, part, due to extension from the naso-pharynx, an in the course of scarlet fever, measles, syphilis, and In some patients, the aural affection is associated wi diseases of the heart or lungs. Exposure to cold an mentioned as the probable cause of the complain patients, excessive indulgence in tobacco and alc have provoked the disease. Hereditary predisposi traceable in this as in other affections of the ear. members of a family are not infrequently found to from chronic aural catarrh. Hereditary predisposi pharyngeal catarrh is often noticed, and when th development of aural disease is only too probable. some authorities, certain anatomical peculiarities panum, *e.g.*, abnormal smallness of the cavity and of are hereditarily transmitted, and these abnormalities to favour the development of aural catarrh.

Affections of the Eustachian tube play a conside the causation of chronic middle-ear catarrh. If thi the ventilation of the tympanum be occluded, th cavity becomes rarefied; and the same effect is pr the tympanic orifice of the tube is blocked up b the lining membrane. Under such circumstances, t tympani is drawn still more inwards, and become parent, and serous fluid may be exuded into the ca the exudation is mucous and viscid, the memb remains depressed; it tends to bulge into the meat its tissue is softened or the quantity of fluid cont tympanum is very large. In severe cases, the tympa the mastoid cells are filled with exudation. The a of chronic catarrh may constitute another stage of

Anatomical Appearances.—In the early stages, t contains more or less exudation, which may be serou muco-purulent in character. It is usually viscid a and adherent to the surface of the lining membrane. The mucous membrane is decidedly thickened, this change depending partly upon small-celled infiltration and increased supply of blood, but mainly upon proliferation of the cellular elements of the membrane itself. The connective tissue is increased in quantity, and contains a large number of spindle-shaped cells; later on, the tissue becomes more fibrous in character and the cells are less abundant. The mucous membrane in the neighbourhood of the fenestræ, and the mucous covering of the ossicles are especially affected; and there is often marked thickening of the membrane lining the floor of the cavity. With the development of the process, the ossicles become embedded in the swollen tissue, and the fenestræ are almost completely hidden from view. Mucous surfaces thus come into contact, and adhesions take place; as the swelling subsides in consequence of retrogressive metamorphosis, bands and membranes extend between the surfaces. The ossicles themselves undergo various changes of an inflammatory character, and the process not infrequently extends from the inner wall of the tympanic cavity to the labyrinth. The formation of exostoses is another result, and ankylosis of the base of the stapes is perhaps the most frequent consequence of disease of the ossicles. The condition is due either to calcareous deposit around the base of the bone or to proliferation of the cartilaginous covering; in other cases, there is true osseous union (synostosis). Similar changes are sometimes found in the articulation between the malleus and incus.

The **Membrana Tympani** is always more or less involved. The change most commonly observed is thickening as a result of hyperplasia of its mucous membrane. When, however, owing to persistent closure of the Eustachian tube, the membrane remains indrawn for a long period, it is liable to become thin and atrophied. When thickened, the membrane appears dull and more or less opaque, and loses its elasticity; these changes are usually most marked at the periphery. Calcareous deposits are sometimes observed.

Subjective Symptoms.—Unless the complaint has supervened upon an acute attack, the early symptoms, in many cases, are of an indefinite character, and the patients are unable clearly to indicate their duration. Deafness is always present; but when only one ear is affected, the loss of function may be unnoticed for a considerable period, and in the case of children, impaired hearing on both sides may be attributed to inattention. Even adults, with both ears affected, are often unaware of any loss of function until the condition has become very pronounced. They unconsciously supplement their hearing-power by lip-reading, and by filling up gaps in conversation by guesswork. It is, moreover, a common habit of deaf persons to attribute their incapacity to imperfect articulation on the part of the speaker, rather than to any defect in their own organs of hearing. Sooner or later, however, in these cases of chronic catarrh, the hearing-power becomes decidedly impaired, so that the patients cannot fail to be aware of their loss. Implication of the cochlea causes loss of hearing-power for high notes. Absolute deafness seldom or never occurs, except as a result of the further stages. Pain is sometimes complained of; it is generally due to exacerbation of the catarrh.

Noises in the Ear constitute another symptom which is almost invariably present. In many cases the tinnitus is the first indication of aural mischief, and the one that causes the patient to seek relief from treatment. In another class, almost or quite as numerous, the tinnitus accompanies the later stages of the affection, and proves very obstinate and troublesome. The noises vary in character and intensity; they are described by different patients as "singing," "whistling," "buzzing," "blowing," "roaring," etc. They are either continuous or intermittent; sometimes they are synchronous with the cardiac pulsations, and sometimes altogether irregular in rhythm. Sounds either of a very high or of a very low pitch for the most part indicate an advanced stage of the disease, with implication of the labyrinth. When only slight, they may give the patient but little trouble; but when loud and constant, they prove very distressing. It is often noticed that they are aggravated by excitement, and by severe bodily or mental exertion, by conditions of exhaustion, and by excessive indulgence in alcohol and tobacco.

Entotic sounds, *i.e.*, those originating in the ear itself or in its immediate neighbourhood, are less often complained of. They are due to clonic spasms of the tensor tympani and the muscles of the Eustachian tube, and can be heard on auscultation. They are synchronous with movements of the soft palate and tympanic membrane.

Giddiness is another somewhat common symptom of chronic aural catarrh. At first the attacks are slight and transient: as the disease progresses, they are apt to become severe and prolonged. They are then often associated with nausea or vomiting, and with increase of the tinnitus. They, in common with the noises, are presumably due to extension of the processes in the tympanum to the external semicircular canal and cochlea. In some cases, loss of memory, inability to concentrate the attention, and a sensation of fulness in the head, are superadded to the giddiness.

Variations in the intensity of the symptoms, and especially in the degree of deafness, are characteristic of the disease, and are sometimes traceable to changes of weather, and alterations in the condition of the naso-pharynx. As a general rule, the patients are worse in all respects in cold, damp weather. The bodily health of the patients often has a decided influence on the symptoms.

Autophony and Paracusis.—Other symptoms, occasionally present in cases of chronic aural catarrh, are autophony and peculiarities of hearing (paracusis). The former, which has been already described (see page 344), consists of reverberation of and echo-like additions to the patient's own voice; and other sounds sometimes undergo like modifications. It is often associated with abnormal patency of the Eustachian tube, which is prone to occur in "dry" catarrh of the middle ear. It is also noticed in cases in which the tube has become impermeable, and may then be attributed to increase of osseous conductivity.

Paracusis Willisii, or hearing improved by noise, is sometimes noticed in cases where the movements of the ossicles are interfered with by swelling and exudation. An increase of stimulus is necessary to cause sufficient vibration; when this is provided, the hearing-power becomes much improved. Such patients can hear better when travelling by railway or in a closed conveyance than when all around them is quiet.

Objective Appearances.—The condition of the tympanic membrane varies in different cases; when the morbid process is mainly confined to the inner wall of the cavity, it may be but little changed. As a general rule, however, the membrane is more or less drawn inwards; the short process projects and the posterior fold is tense and well-defined. The handle of the malleus is drawn inwards and backwards, and sometimes almost covered by the posterior fold, only its extremity remaining visible; the posterior superior quadrant of the membrane is much reduced in size. The cone of light appears smaller, less bright and distinct, and sometimes is interrupted; it may, indeed, be altogether absent. Various alterations are observed in the appearance of the membrane, opacity being the most common change. This may be either uniformly diffused, or scattered in patches over the surface; in the latter case, the posterior segment, between the umbo and the periphery, is apt to be especially affected. Sometimes the opacity is especially marked at the periphery. The colour of the altered portions is bluish-white, and in later stages leaden-grey; the margin is not very clearly defined. The spots may be so thick and dense as to resemble calcareous deposits, which, moreover, are sometimes found associated with chronic aural catarrh. These deposits are decidedly white in colour and crescentic in form, and have well-defined margins.

An opposite condition, viz., a peculiar transparency of portions of the membrane, is sometimes noticed in long-standing cases; it is due to atrophy and loss of substance. When a large portion of the membrane is thus affected, several intra-tympanic structures—*e.g.*, the promontory, long process of the incus, and even the stapes—may become visible.

When the tympanum contains free exudation, which is generally the result of a subacute attack, the opacity of the membrane prevents the fluid from being clearly distinguishable; there may be a light yellowish tinge of the lower half, or one or two dark lines. When the secretion is viscid and mucous, the opacity will be still more pronounced. When cicatrices exist in the membrane and exudation is abundant, the pressure of the latter may cause them to bulge out from the surface of the membrane and form whitish or greenish-grey projections. If the membrane be in a state of atrophy, the level of any existing exudation will be very clearly made out.

The **Injection of Air** affords material assistance in determining the state of the tympanum. Râles of various kinds are heard when exudation is present and air is injected through the catheter. If the Eustachian tube be permeable, absence of sound on injecting air indicates that the secretion is very tenacious and adherent to the walls of the tympanum, or else that it entirely fills the cavity. A rough, interrupted sound indicates that the mucous membrane is relaxed and swollen, and coated in places with tenacious mucus. When some force is required to inject the air, and the sound, at first weak and shrill, becomes stronger and lower in pitch after one or two swallowing movements, some obstruction in the Eustachian tube may be inferred to exist. Complete impermeability is extremely rare. If the sound heard on auscultation be comparatively normal, and the hearing-power be much diminished, the case is probably one of adhesive or "dry" catarrh.

In most cases inflation of the tympanum is followed by decided improvement of hearing-power, which, however, soon passes off. The compressed air forces the membrane outwards, and overcomes, for the time, the secondary contraction of the tensor tympani muscle. On examining with the speculum immediately after inflation, the normal condition of the parts is seen to be restored to some extent: the membrane is less concave, it may even bulge out into the meatus; the short process and the posterior fold are less prominent, and the handle of the malleus is more conspicuous and less horizontal. When exudation is present in the tympanum, the injection of air causes its dispersion; the yellowish tinge disappears, and the line marking the upper surface of the fluid is no longer visible, or else is altered in position. These changes are less distinct when the exudation is of a tenacious character.

In cases of chronic catarrh with perforation, after using the syringe, the short process and the handle of the malleus are usually visible, the membrane is seen to be thickened, whitish-grey in colour, and coated with patches of epithelium; the perforation, which is usually situated in the anterior inferior quadrant, is small, roundish in form, and has its margin everted; through the opening, the mucous membrane of the tympanum appears reddened and thickened.

Bone-conduction.—Unless there be some disorder of the labyrinth, osseous conduction is found to be increased on the affected side; and if both ears be involved, the sound is more distinct on the side on which the symptoms are especially pronounced. Rinne's experiment gives negative results, with diminished air-conduction and increased length of time during which the sound is heard through the bones of the skull. There is sometimes considerable difference between the results of testing by the watch and by speech; but various patients differ very much in this respect.

Course of the Disease.—Chronic aural catarrh always runs a protracted course, and the complaint is apt to prove very obstinate when it has supervened upon disease of the naso-pharynx, or is associated with constitutional disorders. The hearing-power is observed to be more and more impaired; the change for the worse is sometimes slow and sometimes rapid in its progress. Not infrequently, the condition remains stationary for some time, and then becomes worse; spontaneous improvement is seldom noticed. Most patients find themselves better in dry, warm weather; all the symptoms are liable to be aggravated under opposite conditions. In the absence of treatment, the processes upon which the condition depends go on either intermittently or continuously; thickenings of the mucous membrane, adhesions between various parts, induration and chalky deposits, are the ordinary results.

Diagnosis.—Chronic aural catarrh is for the most part easily recognisable. The symptoms already described, and especially the condition of the membrana tympani; the state of the naso-pharynx; the sounds produced and the improvement in hearing when air is injected—these, taken together, indicate the real nature of the case.

Prognosis.—More or less improvement in hearing-power may generally be anticipated, provided that proper treatment be submitted to; and the greater the change for the better after the injection of air, the more favourable the prospect. Several examinations are, however, desirable, before any definite opinion is expressed; the air-douche may at first produce results which are subsequently unattainable. A somewhat lengthened trial is therefore necessary. Politzer's inflation or injection of air through a catheter should be used twice or three times a week for about three weeks, and if no improvement result, the outlook is by no means promising, though much may be done to prevent the condition from becoming worse. If the injection of air fail to improve the hearing, but lessen the subjective symptoms (the noises and the feeling of pressure and fulness in the head), there is reason to hope for satisfactory results. The hearing-power should be thoroughly tested for various sounds, both before and after the employment of the air-douche; differences may be noticeable in the perception of some sounds and not in that of others. When any improvement is detected, its duration should be noted; the prognosis is generally favourable in proportion to the latter.

Certain other circumstances tend to render the prognosis more or less favourable, and may be briefly summarised as follows:—The adoption of treatment in an early stage of the disease, and before marked symptoms have set in; intermittency of the tinnitus; maintenance of bone-conduction; hearing-power for speech and high notes not much impaired; variations in the intensity of the symptoms from time to time; and absence of hereditary predisposition. In cases in which a cure is impossible, much may often be done to cause, at least, temporary improvement, and to prevent the condition from becoming decidedly worse.

Treatment.—Any existing affection of the naso-pharynx must be carefully attended to in the manner already described (see page 274). The local treatment of the middle ear has for its objects the absorption of exudation and the diminution of swelling and thickening of the mucous membrane.

Inflation of the Tympanum is the most important therapeutical measure. It tends to break up adhesions, to remove exudation, and to stimulate absorption; it likewise acts mechanically on the membrana tympani and chain of ossicles, and lessens the pressure on the fenestræ. Air may be injected into the tympanum either by Politzer's method or with the aid of the catheter. The former is suitable for children and for some mild cases of bilateral disease; the catheter is required whenever there is considerable swelling of the Eustachian tube, and also when remedies are to be injected into it. The carrying out of Politzer's plan is sometimes entrusted to patients themselves or to their friends. In such cases, very careful instructions should be given as to the method of employment. On the whole, air injected through a catheter yields better results, but certain precautions are necessary. The instrument should be used daily or every other day for two or three weeks, and afterwards at longer intervals, provided that the symptoms show some improvement. If, after a month's trial, the result be negative, the catheter should be given up, at least for a time. In many cases, the use of the catheter is followed by decided improvement of hearing; but when dealing with old-standing disease in which the deafness has not become perceptibly worse recently, it is best to forego direct treatment to the middle ear, because the stimulation of the parts sometimes brings into fresh activity the catarrhal processes which had become quiescent.

Application of Vapours.—In some cases, the absorption of the exudation is promoted by chloride of ammonium introduced in the gaseous form into the tympanum. The method of using this remedy has been already described (see page 159). Care must be taken that the ammonium is perfectly neutralised, otherwise much irritation may be caused. Decided benefit is not infrequently witnessed in cases that have been little, if at all, improved by the injection of air or solutions; the remedy is indicated in cases of this kind, and when râles continue to be audible after prolonged treatment with the catheter. The vapour should be applied twice or three times a week, and for three or four minutes at a time. Air impregnated with turpentine may be used in a similar manner. A few drops are poured into the air-bag and allowed to volatilise; the air, thus charged with the vapour, is then injected through the catheter. A better plan is to have a small vulcanite box, fitted on to the delivery tube of the Politzer's bag, in which can be placed a piece of wool moistened with the medicament.

Remedies, in a Fluid Form, may likewise be applied to the mucous membrane of the middle ear (see page 156). At first these should be of a comparatively mild character, *e.g.*, solution of iodide of potassium 5—10 grains to the ounce, or solution of borax, alum, carbonate of soda, or chlorate of potash 2—3 grains to the ounce. Afterwards, when the condition has become less acute, solutions of nitrate of silver 3—5 grains to the ounce, or of sulphate of zinc 1—3 grains to the ounce, may be carefully tried. Of these solutions, about two or three drops should be injected with very slight pressure: with larger quantities and stronger solutions, severe pain and some amount of inflammation may be set up. These injections, when they are well borne, may be used twice or three times a week, and continued for several weeks. Alkaline remedies, thus injected, render the secretion less viscid and more capable of absorption.

Besides inflation of the tympanum, there is another method whereby the membrane and ossicles may, in some measure at least, be restored to their original positions. This plan consists in rarefying the air in the external meatus by the aid of Siegle's speculum (Fig. 31, page 89). The larger end of this speculum is closed by a glass disk; an india-rubber tube connected at its other extremity with an elastic bag, opens into the side of the instrument, which closely fits the meatus. Before introducing the speculum the bag is compressed; its expansion, when the instrument is in position, rarefies the air in the meatus, and draws the membrana tympani outwards. When this method is practised, the patients sometimes assert that the hearing-power is increased, and that the subjective sensations are less troublesome.

The **Operation of Paracentesis** (see page 351) is sometimes advisable in cases of chronic catarrh of the middle ear, and especially when the symptoms threaten to become acute. It may be practised with advantage when other methods of treatment have failed to remove the exudation from the tympanum, and also when the cavity appears to be completely filled with tenacious secretion.

For the relief of the subjective symptoms, and with the view of improving the hearing-power, **Plicotomy**, or division of the posterior fold, is recommended by some authorities. The operation has been done when the fold projects and forms a sharp ridge, and when other measures have failed to produce relief. A perpendicular incision is made with a paracentesis knife, through the fold in its anterior half, at a distance of 2—3 mm. from the short process. It is better to cut from below upwards than in the opposite direction. The hæmorrhage is easily stopped with a little cotton-wool; a plug of carbolised gauze should be placed in the meatus. In order to avoid wounding the chorda tympani, the knife should not be thrust too far inwards.

Various other operative measures, having for their objects the relief of tension and the separation of adherent parts, will be described in the chapter on Adhesive Inflammation of the Tympanum.

In all cases of chronic middle-ear catarrh, it is not sufficient to treat the local disease; the patient's general condition always requires attention. Change of air is often beneficial, and is always desirable whenever there is a pronounced tendency to bronchial or pharyngeal catarrh. Residence in a mountainous [illegible] and possessing a mild climate, [illegible] special care is necessary; [illegible] change to a warm climate should [illegible] disorder—*e.g.*, tuberculosis [illegible] treatment. The diet in all [illegible] character; tobacco is generally [illegible] should be enjoined in the use of

Fig. 98.

Ear Protectors.

[illegible] of various kinds, with the water at [illegible] useful accessories in the hygienic [illegible] weather and the patient's general [illegible] e.g. Ward Cousins' india-rubber [illegible] ured in four sizes), Fig. 98, may [illegible] vent the water from getting int

CHAPTER XXVI.

CHRONIC ADHESIVE CATARRH OF THE MIDDLE EAR—OTITIS MEDIA CATARRHALIS SICCA—SCLEROSIS OF THE MIDDLE EAR.

Nature of the Disease—Origination and General Consequences—Pathological Appearances—Causes—Symptoms—Impairment of Hearing—Subjective Sensations—Hyperæsthesia Acustica—Paracusis—Objective Appearances—The Membrana Tympani—Contraction of Tensor Tympani Muscle—Condition of the Naso-Pharynx and Eustachian Tubes—Testing the Hearing-Power—Course and Termination—Diagnosis—Prognosis—Treatment—Attention to Naso-Pharynx—The Air-Douche—Application of Remedies to the Tympanum—Solutions of Pepsin and Papain—Rarefaction of Air in the Meatus—Politzer's Plan—Lucae's Spring Pressure-Probe—Hommel's Method—Treatment of the Tinnitus—The Eustachian Tubes—General Hygienic Rules—Operations Proposed—Removal of Tympanic Membrane and Ossicles—Establishment of an Opening in the Membrane—Division of the Posterior Fold of the Tympanic Membrane—Division of the Anterior Ligament of the Malleus—Multiple Incisions into the Tympanic Membrane—Division of the Tendon of the Tensor Tympani Muscle—Indications for Operation and Various Methods—Results.

THIS form of catarrh is characterised by a great variety of symptoms and morbid appearances. The processes developed in the tympanum tend especially to the formation of adhesions between many parts of the middle ear, and thus lead to serious impairment of hearing. The various changes do not always originate in abnormal secretory processes. In the absence of any previous catarrh, an insidious interstitial inflammation may become developed in the mucous membrane, with thickening and subsequent contraction as results. The ligamentous apparatus is similarly affected, and, as a consequence, the ossicular chain becomes more or less rigid, and the stapes frequently becomes ankylosed. It is not, however, possible to draw a sharp line of demarcation between secretory catarrh and adhesive processes as a further development. The anatomical changes which are at the base of the latter may be developed during the catarrhal stage, and continuously with it, as well as after its subsidence.

This form of middle-ear disease, whether originating or not in catarrh, is especially prone to be accompanied by symptoms indicative of disorders of the labyrinth. Those insidious forms which result in ankylosis of the stapes are more often associated with the latter affections than adhesive processes originating in catarrh. It is quite true that in the course of chronic exudative diseases of the middle ear, secondary changes in the labyrinth are not infrequent complications, but in connection with purely adhesive processes, labyrinthine disorder may exist from the very beginning. In such cases it is fair to assume that the disease in both portions of the ear is attributable to the same cause; as a matter of fact, indeed, the labyrinthine disorder is sometimes so prominent at an early stage, that it would appear to have been developed prior to the origination of the disease in the tympanum.

We are not as yet able to separate those forms of the disease which begin in catarrh from such as are independent of that condition. The prominent symptom, impeded conduction of sound, is common to both cases.

Pathological Appearances.—These have been especially studied by Politzer, who has given a very minute description of them in the second and third editions of his work. The following account is mainly derived from Politzer's statements:—The changes are either diffused over the whole of the mucous membrane, or are confined to certain parts of it. The former condition would seem to result from secretory catarrh; while the latter is produced by interstitial inflammation, and the parts most liable to be affected are the fenestral structures and recesses. The changes in the mucous membrane consist of partial or complete conversion of the proliferated round cells into cicatricial tissue, and of increase in the substance of the mucous membrane, followed by regressive metamorphosis, shrinking, sclerosis, atrophy, and calcification.

When the secretory stage is still in progress, the mucous membrane is hyperæmic, irregularly swollen, of a yellowish-red colour, spongy in texture, and infiltrated with serum; its surface is uneven, and marked by glandular or villous projections. The concavities, and particularly the fenestræ, are levelled and less apparent, and the cavity as a whole is more or less diminished. The tympanic portion of the Eustachian tube is narrowed, and the mastoid cells are filled with secretion. The mobility of the ossicles is lessened, but not as yet abolished. Partial recovery is possible as a result of fatty degeneration of the proliferated round cells.

In another class of cases the secretory processes have come to an end, and the conversion of the hypertrophied elements into fibrous connective tissue has already taken place. The mucous membrane is smooth, thickened, pale, and stiff, closely adherent to the underlying parts, and presenting calcareous patches. These changes affect not only the lining membrane, but also its folds and the ligaments and the tissue covering the articulations; the thickening is generally most marked at the points of contact between the ossicles and the walls of the cavity. The functions of the tympanum are still further impaired by the formation of membranous cords and bands, running in various directions and connecting together the ossicles, the tympanic membrane, and the tendon of the tensor tympani muscle. Some of these cords can be traced to the wall of the cavity, and are sometimes partially ossified. Another serious change is the adhesion of the membrane to the inner wall; and if this be accompanied by the formation of bands and cords and the development of exostoses, the tympanic cavity will be almost or quite obliterated.

The general result of all the above-described changes will be: diminished vibrating power of the tympanic membrane and ossicles, and impeded conduction of sound. The most serious consequences result from adhesions of the ossicles to the tympanic walls and ankylosis of the articulations, and especially of the stapes to the fenestra ovalis. In some cases the morbid process appears to be confined almost entirely to the fenestræ, and especially to the upper one and its union with the stapes. On the other hand, the changes in these parts may be, and often are, associated with adhesions and the formation of bands of membrane, as already described.

The ankylosis of the stapes may be caused by the union of

is similarly affected, and, as a conseq
becomes more or less rigid, and the
ankylosed. It is not, however, possil
demarcation between secretory catarrh
a further development. The anatomic
base of the latter may be developed
and continuously with it, as well a
This form of middle-ear disease, w
catarrh, is especially prone to be acc
cative of disorders of the labyrinth.
result in ankylosis of the stapes ar
the latter affections than adhesive p
It is quite true that in the course o
the middle ear, secondary changes
quent complications, but in con
processes, labyrinthine disorder m
ning. In such cases it is fair to
portions of the ear is attributable
of fact, indeed, the labyrinthine
nent at an early stage, that it wo
prior to the origination of the di
We are not as yet able to s
which begin in catarrh from
condition. The prominent s
sound, is common to both ca

Pathological Appearances.—
by Politzer, who has given a
the second and third editi
account is mainly derived
changes are either diffused
brane, or are confined to cer
would seem to result from
produced by interstitial infl
be affected are the fenestral
in the mucous membrane
of the proliferated roun
increase in the substanc
regressive metamorpho
calcification.

When the secretory

by adhesion o
occurrence of th
the two parts a
ains of the gelo
of the footplate
ing, to prolifera
to deposit of oss
and over the fen
o important cha
tissue, or much
itself is thickene
ankylosis betwe
ition sometimes
articular surfaces
adherent to each
ube vary in differen
aracter and connec
s, the canal is apt t
the mucous memb
In interstitial infla
the tympanum, the I
tance and calibre.
muscles, whereby t
ed with. Thus fatt
ation are occasional
are liable to pres
mation of the adja
tion due to ankylosis
ase of the muscles n
f the stapes.
of the
anatomy of ad
hibits the differen
rrhal and purule
tion to increase
ous, serous, or pur
ally proportionate
ive inflammation
hat the exudation
quantity. In m
ssue elements

exudative inflammation, the tympanum may contain more or less mucous or purulent secretion.

Causes.—Adhesive middle-ear inflammation is due to much the same causes as the catarrhal form, but the process is always chronic. It differs from the ordinary catarrhal inflammation, inasmuch as it generally attacks persons in middle or advanced age. With regard to antecedent conditions, the complaint sometimes follows chronic naso-pharyngeal catarrh, and conditions involving paralysis of the muscles of the Eustachian tubes, whereby the ventilation of the tympana is interfered with. Sometimes there is a history of syphilis, gout, or rheumatism; hereditary predisposition to aural disease is often traceable. The patients, however, are more often plethoric and robust than in cases of catarrhal inflammation. Exposure to cold and wet, to the action of dust, as in certain occupations, frequent and prolonged sea-bathing, and excessive indulgence in alcohol and tobacco, are more or less potent causes of the disease, and they certainly aggravate the condition, when once set up. All classes of persons are equally prone to suffer from the complaint. As in the case of catarrhal inflammation, the adhesive process generally affects both ears simultaneously (86 per cent.), or in rapid succession: in rare cases, one ear is thus affected, while the other is the seat of catarrhal inflammation. In unilateral cases (14 per cent.) the left ear is more often affected than the right (8·2 : 5·8).

Symptoms.—When the parts concerned in the conduction of sound are not primarily involved, the process may go on slowly for months or years without causing any decided symptoms. If, however, the vibrations of the membrana tympani and ossicles be impeded, the patient will be conscious of impairment of hearing, of a feeling of pressure and fulness in the ears, and of subjective auditory sensations. There is no particular pain, but giddiness and mental and nervous disturbance may be very troublesome. The symptoms once established steadily progress, and herein they differ from those of the catarrhal form. In some cases the symptoms correspond with those of Ménière's disease.

As time goes on, the hearing becomes more and more impaired, and the noises in the ears louder and more annoying. Not infrequently the patients complain that whereas they can hear simple sounds, they fail to hear words addressed to themselves, and are therefore unable to carry on conversation. The advance of the symptoms is due in part to the continuous formation of tissue in the tympanum, and partly to the secondary changes which become developed. Contraction and shrinking take place, with increased rigidity of the joints of the ossicles and abnormal position of these bones. Thus the function of the conducting apparatus is seriously impaired, and secondary changes are liable to occur in the labyrinth, though, as already pointed out, the internal ear may have been implicated from the commencement. Labyrinthine disorder cannot fail to aggravate the impairment of hearing which results from changes in the tympanum, and the deafness is influenced to some extent by the condition of the Eustachian tube; if the mucous membrane be swollen or thickened, the hearing-power will be diminished. The deafness is also liable to be aggravated by excesses of all kinds, and by fatigue and debility. In a somewhat numerous class of cases, the perception of low notes is lost at an early stage; whereas hearing for the highest octave remains good for some time.

The **Subjective Sounds** vary in character, and are variously described by different patients as "humming," "buzzing," "knocking," "whistling," "blowing," "ringing," etc. The noises may appear to emanate from outside the head, or in the ear itself, or in some part of the skull. In some patients noises of various character co-exist, or succeed each other. They are generally continuous and uniform; but sometimes they cease for short intervals. The distress caused by the noises is very severe in some cases.

There are no other definite symptoms of a subjective character. Pain in the side of the head, giddiness, a feeling of confusion or heaviness, or of pressure about the occiput, restlessness, depression of spirits, and diminished capacity for mental work, may be complained of from time to time. The defective hearing and the subjective sounds are the marked symptoms. In some cases, in the early stages of the disorder, but still more frequently after the hearing has become much impaired, great sensitiveness is evinced towards various sounds, especially high notes and loud talking (*Hyperæsthesia acustica*).

There is another symptom which is not infrequent in this form of ear-disease, viz., improvement of hearing during a noise, the so-called "paracusis" of Willis. This author described a case in which a man's voice could be heard by his deaf wife only while a servant was beating a drum. This phenomenon will be further described in the chapters on Affections of the Labyrinth; its probable cause may here be briefly alluded to. Politzer * thinks that improved hearing in a noise is due to the severe shaking of the ossicles, the articulations of which have become stiff. Their normal condition is in some measure restored, and they are rendered more capable of conducting sonorous vibrations. Löwenberg suggests that the shaking produces increased excitability of the auditory nerve, and consequent augmentation of hearing-power.

Objective Symptoms.—These exhibit differences according to the stage of the complaint, the parts principally affected, the intensity of the process, the previous condition of the part, and the predominating character of the inflammation. The symptoms caused by purely adhesive processes differ from those in which the catarrhal element has been more or less prominent.

On inspection, the external meatus is generally found to be very dry; there is little, if any, ceruminous secretion. The patients themselves often notice this deficiency, and regard it as the cause of their symptoms.

The appearance of the membrana tympani varies greatly; its sensitiveness is often much reduced. There may be little, if any, change in position, lustre, or transparency; in other cases, the membrane is seen to be cloudy, dull, and either thickened or atrophied and parchment-like. Abnormal transparency is associated with atrophy. An almost normal appearance of the membrane may co-exist with very serious impairment of hearing; in such cases, the morbid process is confined to the fenestræ and ossicles. The membrane is generally drawn inwards or sunken, and obviously adherent to parts situated on its inner side. Hyperæmia of the inner wall of the tympanum often imparts a characteristic tint to the membrane, causing it, in some cases, to assume a peculiar dry, dusky-red appearance. In others, a reddish-yellow spot, with a diffuse red areola, corresponding with the promontory, is seen behind the handle of the malleus. Such evidences of hyperæmia may remain unchanged for several years; and even after the membrane has become dull and opaque, traces of the reddish tint may be discoverable here and there. Sometimes the reddish tinge is especially marked in the posterior inferior quadrant, near the umbo, and this appearance is apt to be associated with injection of the vessels of the handle of the malleus. This condition of the parts often accompanies synostosis of the stapes; but its existence cannot be detected when, as is often the case, the membrane is thickened and opaque. In exceptional cases, the peripheral part of the membrane appears as a whitish ring, while the remainder is normal in colour. Calcareous deposit, causing a decided white opacity, is sometimes visible in front of the handle of the malleus. Less frequently, a similar spot exists behind that part.

---

* *Lehrbuch der Ohrenheilkunde*, 2 Aufl. S. 239.

Another change, more or less frequently observed in cases of sclerosis of the tympanum, is a peculiarly white colour, sharp definition, and roughened surface of the handle of the malleus. A pit-like depression of Shrapnell's membrane is also regarded by some writers as characteristic of sclerosis and the adhesive processes. These appearances are, however, by no means constant, and they have been noticed in association with other morbid processes.

When Siegle's speculum is used, the central part of the membrana tympani is found to be decidedly movable in some cases and fixed in others. The former condition is often the result of atrophy, while the latter is caused by interstitial deposit and induration of the mucous membrane. It must be remembered that other processes in the middle ear often precede the development of sclerosis or adhesive inflammation, and produce changes in the membrane and other parts, which complicate the appearances due to the latter process.

Proneness to contraction is exhibited not only by the newly-formed bands of connective tissue, but by the tendinous structures within the tympanum, and the condition of the tendon of the tensor tympani muscle is of serious import during the course of the disease. The entire chain of ossicles is acted upon by the increased tension and rigidity of the muscle, and the intra-labyrinthine pressure is considerably raised.

Gruber has pointed out that as a result of the contraction of the tensor tympani muscle and also of shortening of its tendon, the malleus is not merely drawn inwards, but turned round upon its long axis, this latter movement being due to the fact that the tendon is inserted into the inner margin and anterior surface of the handle. The direction thus given to this surface is somewhat internal, while the opposite surface is directed outwards, thus making the handle appear broader when viewed from the external meatus. This alteration in the appearance is of diagnostic value, but it may be absent when the tendon is contracted. Individual peculiarities in the insertion of the tendon and in the structures connected with the malleus, to some extent influence its movements and the secondary consequences of retraction of the tendon. Thus, even when this latter condition is present, some portions of the membrana tympani may remain normal as regards their tension, while others are abnormally stretched, and others again relaxed and thrown into folds.

The **Naso-pharynx** is always more or less affected. In the earlier stages, the mucous membrane covering the posterior wall is frequently swollen, dark red in colour, and dotted over with granulations of various sizes, either isolated or in patches. In other cases, the membrane is smooth, dry, and shining. When the condition has existed for some years, the mucous covering of the pharynx is seen to be abnormally pale and thin. It adheres closely to the parts beneath, and patches of brownish secretion are scattered over the surface, which is traversed by a few enlarged vessels.

The nasal mucous membrane is dry, and sometimes presents the appearances of atrophic rhinitis. The patients assert that they seldom require to use a pocket-handkerchief; the secretion from the nose is reduced to a minimum.

Various changes are likewise noticeable in the **Eustachian tube.** In young subjects with granular pharyngitis, the mucous membrane of this part is apt to be similarly affected; the tube is narrowed, the auscultation-sound when the catheter is used is weak and high, and more force is required to compress the air-bag. In later stages, the mucous membrane is dry and the tube easily permeable; slight force is necessary to propel the air, and the sound is distinct and hard. As a result of the air-douche, either the hearing may be unaffected, or the patient may be conscious of slight and transient improvement; while the subjective sounds are often considerably diminished, and the feeling of dulness and heaviness is much ameliorated. If the hearing-power be *decidedly* increased by catheterism, we may safely conclude that the affection is comparatively slight. On examining the membrana tympani after inflation, no particular change may be discernible. If the force of the air has really acted on the membrane, there will probably be more or less bulging of the posterior superior quadrant, with a diffuse pale reflex of light there, and also injection of the vessels along the handle of the malleus.

Results of Testing the Hearing-Power.—In the early stage of the complaint, when perhaps occasional tinnitus in one ear causes the patient to seek advice, the impairment of hearing is often so slight as to be scarcely recognisable on testing with the watch and speech. In such a case, however, on applying the tuning-fork to the vertex, the patient not infrequently asserts that he hears the sound more distinctly on the side on which the tinnitus exists. It may then be inferred that some obstacle to conduction is present in the middle ear, though perhaps of so slight a nature that no difference can be detected between the two ears when the tuning-fork is held in front of them.

Rinne's test may give a positive result, because the slight obstacle to the transmission of sound is easily overcome by the force of the vibrations conducted by the air to the ossicles, and the duration of perception is not appreciably shortened. As time goes on, the disorder of function becomes much more decided in the ear first attacked, and the other ear is more or less involved, as shown by the diminution in hearing-distance. On the one side, the watch may be heard only when in close contact with the auricle; on the other, perhaps at one-half or one-quarter the usual distance. Bone-conduction may be good on both sides, or weak on the more affected side, or entirely abolished. The hearing-power for speech may be such that with the worse ear very loud talking is heard at a distance of three or four yards, while with the other ear whispers are heard at the same distance. The tuning-fork on the vertex is best heard by the more affected ear; but when held in front of the ears, by the less affected organ. Rinne's test may still give a positive result; but the duration of perception (with the fork held in front of the ear) is more or less diminished. If, moreover, the labyrinth be not implicated, the duration of perception through the air will be lessened relatively to the duration of bone-conduction.

In a subsequent stage, the hearing-power becomes more and more impaired, and this is the ordinary course of the complaint. In a small proportion of cases, the condition having advanced to a certain point remains stationary for some years, or even up to the end of life. The watch is unheard, even when in close contact with the auricle, on the side most affected; loud speech is inaudible at a greater distance than two or three feet. On the other side, the hearing-power may be less impaired.

In comparing the two sides it is often difficult to exclude the better ear, as some amount of sound reaches it even when stopped with the finger. In order to determine the side on which loud speech is really heard, a hearing-tube should be placed in the worse ear, while the other is stopped as closely as possible with the finger. A few words are then uttered in a moderately loud voice close to the mouth of the tube, and then at a little distance from and at the side of the latter. If these last are repeated by the patient, it is evident that he has heard them with the better ear.

When the deafness has become so marked in the ear first affected as to be almost absolute, the process, as a general rule, goes on much more rapidly in the other ear, and before long the impairment is found to be much the same on both sides. When this stage is reached the watch is inaudible, and loud talking is heard only close to the ear. If, however, the ossicular chain is not quite rigid or the fenestræ completely blocked up, the patient will hear words spoken through a hearing-tube. It sometimes happens that the final stage of ankylosis supervenes very rapidly; words spoken through a tube are then no longer heard, but bone-conduction may still exist, as shown by the power of the patient to repeat words spoken close to the side of the head.

In this final stage Weber's test gives doubtful results. If, however, the obstacle in one ear be increased by plugging the meatus tightly with the finger, the tuning-fork on the vertex is generally best heard on that side, unless the auditory nerve be decidedly implicated. Rinne's test gives negative results on both sides; shortened duration of perception when the tuning-fork is applied to the mastoid process indicates disease of the labyrinth.

Course and Termination.—In the large majority of cases, the symptoms become more and more marked as time goes on. Differences in their progress are noticed in different individuals, and are sometimes dependent upon pathological conditions of

safely conclude that the affec ... ate and hygiene,
examining the membrana tymp ... he degree in which
change may be discernible. ... ial localisation of
acted on the membrane, th ... gradual and slow in
bulging of the posterior sup ... apid, and a severe
reflex of light there, and al ... ult. Implication of
handle of the malleus.

Results of Testing the H ... ere are often intervals
the complaint, when perhap ... any change can b
the patient to seek advic ... ubjective symptoms ar
so slight as to be scarcely ... rinth is not involve
and speech. In such a ... ring may rapidly becon
fork to the vertex, the p ... ledinger,* in which t
hears the sound more dis ... es of the right ear, t
exists. It may then be i ... ound normal only a y
is present in the middle ... the process was thor
that no difference can be ... sations, which would
tuning-fork is held in fr ... been correspondi

Rinne's test may ... ersons with hereditary
obstacle to the transm ... catarrh sometimes ca
force of the vibrations ... plication of the labyri
duration of percepti ... the development of sec
goes on, the disorder ... a much later period.
the ear first attacked ... to the fact that in cas
as shown by the di ... hearing on one side onl
side, the watch may ... become affected. When
auricle; on the oth ... the disease in the latt
distance. Bone-con ... very rapid. After a
the more affected ... marked in the ear last at
for speech may be ... the symptoms had
is heard at a dist
ear whispers are
on the vertex ... dle ear spontaneous i
held in front ... urs, it is due to disint
may still giv ... tissue. Sometimes
(with the fork ... ntion of acute inflam
If, moreover, ... nd this is accompa
perception th
duration of h

In a sub

---

p. 47.

kunde, 2 Aufl. S. 241.

Diagnosis.—This is based upon an examination of the membrana tympani and the Eustachian tube, upon the history of the case, the subjective symptoms, and the results yielded by testing the hearing. With regard to the tympanic membrane, the changes to be looked for are an indrawn or sunken condition, alterations in tension, partial or general thickening, atrophy, or calcareous deposits. The condition of the Eustachian tube, and, to some extent, that of the tympanic cavity, can be determined by auscultation during the injection of air either by means of Valsalva's or Politzer's method, or with the aid of a catheter.

It is all-important to distinguish between adhesive catarrh, with its results upon the sound-conducting apparatus, and labyrinthine affections. The diagnosis is sometimes attended with great difficulties, and the frequent co-existence of the two affections must always be kept in mind. When adhesive inflammation alone exists, osseous conduction is unimpaired; but when the labyrinth is involved, the vibrations of the tuning-fork applied to the head are either not heard at all, or very indistinctly perceived. If, with this loss of osseous conduction, there be increasing deafness and continuous noises in the ear, disease of the nervous apparatus may be affirmed to exist.

The methods of using the tuning-fork in diagnosis have already been described (see page 98). When a positive result is obtained with Weber's experiment—that is, when a tuning-fork applied to the head is heard best on the affected side—disease of the middle ear is indicated. Rinne's test (see page 102) is of less value than Weber's (see page 99), though opinions differ considerably on this point. Gruber * takes as an example a case in which, as a result of hyperplasia, there is rigidity of the fenestra ovalis and rotunda, with disorder of sound-conduction, but the labyrinth remains intact. In such a case Rinne's "positive" experiment is successful; but the tuning-fork held before the meatus is heard for a shorter time than under normal circumstances. Gruber asks whether exactly the same result may not be obtained from a patient with labyrinthine disease not far advanced, and he answers this question in the affirmative. And if a negative result be yielded, it is evident that the same might be expected in both diseases, so that as a means of positive diagnosis Rinne's test is not to be relied on.

---

* *Lehrbuch der Ohrenheilkunde*, 2 Aufl. S. 480.

the naso-pharynx, upon the influence of and the presence of constitutional disorders. the hearing is impaired depends upon the the morbid processes. The loss is generall its progress; in some cases the process degree of deafness is the corresponding the labyrinth is always a serious feature.

During the course of the symptoms t of varying lengths, during which little detected. So long as tinnitus and other absent, it may be inferred that the la but even in cases of this kind the he impaired. In a case recorded by Dr. autopsy showed ankylosis of all the os hearing-distance had been tested and before death. The rapid development to explain the absence of subjective s have been wanting had the labyri affected.

In syphilitic subjects, and in p disposition to aural disease, adhesiv total deafness, which results from The aural complaint may accompa ary symptoms, or may supervene a

Politzer † draws special attent adhesive catarrh with impairment still normal ear is very liable t extension occurs, the progress o is seldom chronic, but general interval, the impairment is mor than on the other side, in w possibly for several years.

In adhesive catarrh of th ment is extremely rare; when and absorption of the newly- dition is complicated by the either catarrhal or suppur aggravation of all the symp

---

* Archives of Oto

† Lehrbuch der

---

uest
teral
g-pow
onducti
uit witl
ature res
ural par
e disord
n many
being u
e sound-cc
ainty when
uit which
e sound is
n some meas
on Weber'
apparat
—that i
's test be
the sound-co

mbrana ty
the state c
d while air
ed in the m
the membra
herent, are bu
and are seen
return to thei
No such cha
place. Strands c
the inner wall
attached parts
mobility, and m

the tension in th
extent without le
the membran
inspection alone.
dull, it may appe

examined with Siegle's speculum to be much relaxed; and a membrane apparently normal on inspection may prove to be in a state of tension. Slight alterations in this latter condition cannot be diagnosed by means of the pneumatic speculum; but excessive mobility and an opposite state of the membrane point respectively to diminution and increase of tension, and free movement of the handle of the malleus excludes the possibility of ankylosis between this bone and the incus. There is one clinical fact of considerable importance, viz., that only slight deafness is often observed associated with great tension, and still more often with decided relaxation of the membrane, and an altered position of the handle of the malleus, this part of the bone being drawn decidedly backwards and inwards.

Prognosis.—The prognosis in adhesive middle-ear catarrh is for the most part unfavourable, only in a small proportion of cases can any improvement be effected by treatment. A return to the normal condition, or even a cessation of the morbid process, is very exceptional. In most cases, notwithstanding treatment, the symptoms steadily grow worse, until the deafness becomes very marked, as a result of ankylosis of the ossicles. Many years may, however, elapse before this stage is reached. Absolute deafness does not occur unless the labyrinth be profoundly implicated. The prognosis is unfavourable in cases in which Ménière's group of symptoms is observed, and in which the noises in the ears are very troublesome, and are not relieved by the use of the air-douche. If the subjective sensations be continuous, and accompanied by impairment of bone-conduction, improvement is all but impossible. There are, of course, many grades in the disease, and the prognosis is influenced by the circumstances connected with individual cases. A previous history of naso-pharyngeal catarrh and of catarrh of the tympanum renders the prospect more favourable than it must be in the absence of such symptoms, when the case is probably one of insidious adhesive inflammation, coupled with disease of the labyrinth. The prognosis is *comparatively* favourable when the hearing is not much impaired; when the subjective sensations are either absent or not very marked; when osseous conduction is not diminished, and when the symptoms are decidedly improved after the air-douche. It is unfavourable under opposite circumstances, especially when these are accompanied by a normal appearance of the membrana tympani and permeability of the Eustachian tube. Cases in which there is diffused redness of the labyrinthine wall are generally characterised by rapid progress of the symptoms; and, finally, by marked deafness. Rapid diminution of osseous conducting power is of evil import. With regard to general and individual conditions as affecting the prognosis, it may be stated that the prospect is unfavourable in old persons, and in the subjects of cachexia, and especially in those with a syphilitic history. The prognosis is likewise bad in drunkards, and in persons whose avocations expose them to cold and damp. Hereditary predisposition to aural disease is another unfavourable circumstance.

In a large number of cases, a trustworthy prognosis cannot be given until the patient has been seen several times and the result of treatment carefully noted. The surgeon may then be able to form an opinion as to whether improvement may be expected, whether the disease will go from bad to worse, or whether the patient's condition as regards hearing and other symptoms is likely to be maintained.

Treatment.—In cases of adhesive catarrh of the tympanum, the throat should be examined in order to see whether any symptoms of catarrh are present in the naso-pharynx. If the mucous membrane be hyperæmic, swollen, and relaxed, an endeavour should be made to effect an improvement by the remedies mentioned in a previous chapter (see page 274). In most cases, however, no evidences of any recent affection will be found in the throat, and the treatment must be directed to the tympanum itself. The condition of the Eustachian tube and the general state of the patient will, of course, require attention.

In adhesive inflammation of the middle ear, restoration of the mobility of the affected parts and arrest of the progress of the disease are the primary aims of treatment, and these results may sometimes be achieved by the employment of the air-douche. Improvement of hearing-power and lessening of subjective sensations and other head-symptoms are certainly feasible in some cases. Valsalva's method of forcing air into the tympanum is not to be recommended for the purposes above mentioned; the choice lies between Politzer's plan and the employment of the Eustachian catheter. According to its inventor, the former may be tried whenever the tubes are pervious; the catheter is indicated when there is obstruction to the passage of air. Politzer states that in cases of the latter kind the injection of air through a catheter may not only improve the hearing, but also considerably relieve the subjective symptoms, and that its efficacy in these respects is often greater than that of his method.

Great caution and gentleness must be exercised in using the air-douche; a prolonged course of such treatment may have a very prejudicial effect upon the condition intended to be relieved. The douche should be used every second or third day, and thus continued for about four or six weeks. The patient must then be examined from time to time, and if there are evidences of renewed progress of the symptoms, another course of the air-douche should be recommended. This plan should have a fair trial; whenever possible, the air-douche ought to be used in short courses, extending over many months, or even several years. As a matter of course, if the symptoms are aggravated by this method of treatment it is useless to persevere with it. It not infrequently happens that Politzer's method decidedly increases the subjective sensations, and especially the feeling of pressure within the ear. Under such circumstances its use is altogether contra-indicated.

Application of Remedies to the Tympanum.—The effects of the air-douche are purely mechanical; the application of remedies to the tympanum is the next subject for consideration. Such remedies may be employed either in the form of solution or in that of vapour; solutions are now generally preferred. Their effects are, to a considerable extent, due to the force of the current of air which conveys them to the tympanum; but some of the remedies have a relaxing effect upon the stiffened tissues, and thus facilitate the action of the injected air. It is also possible that some amount of absorption may result from the irritation set up by the remedies. Before using the injections in the manner about to be described, the air-douche should be employed to dilate the Eustachian tube, and to remove any mucus which it may contain.

Fluid should not be injected directly into the tympanum, on account of its liability to set up acute inflammation of that region. When a lotion is used, one or two drops of the warmed solution should be injected into a catheter—held horizontally after it has been placed in position—and then propelled through the

Eustachian tube by means of an air-bag. By this method the fluid is carried into the middle ear in the form of spray, and all the beneficial action of the lotion is obtained without the risk attending the injection of several drops of fluid into the tympanum.

Many drugs have been employed for injection into the middle ear; the principal are borax (1—2 per cent. solution); bicarbonate of sodium (1—10 per cent.); chloride of ammonium (1 per cent.); nitrate of silver (·5 per cent.); perchloride of mercury (1 per cent.); iodide of potassium (3 per cent.); chloride of sodium (3 per cent.); and caustic potash (·25 per cent.). Politzer recommends the following solution:—℞. Sodii Bicarb. ·5; Aquæ Destill. 10·0; Glycerin. pur. 2·0. This solution causes but little irritation, either of the tympanic mucous membrane or of the throat. The same author states that he has obtained satisfactory results in several cases from injections into the tympanum of five or six drops of a 2 per cent. solution of pilocarpin. The injection is often followed by slight salivation and increase of perspiration. In cases of syphilis the solution of the iodide of potassium should be employed, appropriate constitutional treatment being at the same time adopted.

In applying remedies to the tympanic mucous membrane, those which produce a marked reaction must be scrupulously avoided. Experience shows that inflammation thus set up is wont to be followed by bad results, and notably by rapid impairment of hearing-power. There is always risk of producing hyperæmia in the tympanum and a congested state of the diseased portions.

If this treatment be continued for from four to eight weeks, or even for a shorter period, the injections being used every second or third day, considerable improvement in the hearing-power will frequently be noticed, and when this is not the case the subjective sensations and the unpleasant feelings in the head will often be ameliorated. As a general rule, it may be stated that if no improvement take place after two or three weeks' treatment, no benefit can be expected from this method.

Remedies can also be applied in the form of vapour, the medicines most often used in this way being chloride of ammonium, turpentine, carbonate of ammonium, iodine, acetic acid, and various balsams. Politzer states that he has obtained the best results from iodic ether. He uses the vapours of chloride of ammonium and turpentine, by way of experiment, in cases in which injections have proved useless owing to a swollen condition of the Eustachian tubes. The method of applying vapours to the tympanum has been described in a previous chapter (see page 159).

It would appear that the air injected with the fluids and vapours is the main factor in causing an improvement. In many cases, however, the combination of fluids or vapours much increases the effect of the air-douche. Fluids, as already stated, would seem to be more effective than vapours. Von Tröltsch recommends a combination of the two methods; after injecting steam for a short time, he employs a stimulating fluid.

When the method of treatment by injections is being pursued, the state of the symptoms must be carefully watched. Should any change for the worse take place, either the injections should be altogether discontinued or the air-douche alone used.

Attempts have been made to act upon the pseudo-membranous formations, bands and adhesions met with in adhesive catarrh, and cicatricial tissue the result of chronic suppuration, by introducing into the middle ear solutions of ferments capable of dissolving albumen. Experiments have proved that various forms of epithelium and connective tissue can be dissolved, to a greater or less extent, by solutions of pepsin and papain. The gastric juice of the dog is a far more powerful solvent, and more rapid in its action, than that of the pig, sheep, or calf; dog's pepsin has therefore been selected for treating cases of deafness due to adhesive catarrh and to chronic suppuration. The proportion recommended[*] is 1 : 10,000, with the addition of ·15 per cent. of hydrochloric acid; and the quantity to be injected varies from ½ to 3 decigrammes. The instrument employed is a Koch syringe suitably modified; the cannula is bent at an angle, and a piece of rubber tubing is interposed between the bulb and the glass cylinder. When the tympanic membrane is imperforate, the injection is made as near as possible to the stapes, *i.e.*, behind and near the upper half of the handle of the malleus. The solution is then likely to reach the niche of the fenestra ovalis with the stapes. The patient should be lying down, with his head on a low pillow and his face turned towards the opposite side. He should remain in this position for an hour after the injection.

---

[*] "A New Method of Treating Deafness," by Dr. Cohen-Kysper, *Archives of Otology*, vol. xxvi., 1897, p. 158.

It is claimed that, when the solution comes into contact with cicatricial tissue, when the stapes is imbedded in a cicatricial membrane and the mucous membrane is coated with epidermis, an actual digestion of tissue takes place. In many cases, within an hour after the application, the hearing-power is decidedly improved, and this result may become permanent.

In cases of suppuration, when the discharge has ceased and a perforation exists, the procedure is very simple. It is sufficient to use a few drops of the solution; a plug of cotton-wool is then placed in the meatus, and the patient should remain for an hour in the recumbent position. Signs of local irritation may appear; but they generally subside in the course of a few days. When a 5 per cent. solution of papain is used, copious exudation may be expected. It must be remembered that the solutions attack only superficial layers of tissue; they produce no effect upon chalky deposits, ankylosis of the articulations, and other severe and extensive changes. No benefit can be expected unless whispered speech is still heard near the ear. In suitable cases, the subjective symptoms, as well as the hearing-power, are decidedly improved. This result was obtained in more than two-thirds of the total number (150) thus treated by Dr. Cohen-Kysper.

Rarefaction of the Air in the external meatus will sometimes assist in rendering the membrane more capable of movement and improving the hearing-power. The process is effected by means of a small india-rubber bag, about 2½ inches in diameter and connected with a tube, about a foot long, terminating in an olive-shaped nozzle, fitting closely into the meatus. To use the instrument, the bag is compressed so as to drive out the air, when the nozzle is fixed tightly in the meatus; pressure is then taken off the bag, with the effect of producing rarefaction of the air in the auditory canal and exerting traction on the membrane. This process may be repeated four or five times at one sitting. The bag may be dispensed with, the patient being instructed to apply his mouth to the tube, and thus alternately to exhaust and condense the air. Siegle's pneumatic speculum (see page 89) and Delstanche's *masseur* can be used for the same purpose. Politzer also recommends a gradual rarefaction of the air, effected by the hermetical occlusion of the external meatus. When this has been accomplished, the action of the atmospheric pressure upon the membrane is suspended and the inward collapse of the latter is prevented. A plug of cotton-wool, as large as a hazel-nut and moistened with oil, is passed into the external part of the cartilaginous portion of the meatus. When the canal is properly occluded, a watch will be heard only on contact with the auricle. The plug should be introduced in the evening and allowed to remain till the morning, and this plan should be persevered with for two or three weeks. Lucae's method * appears to be also of service in some cases in which the membrane is much drawn inwards. He employs a small instrument which he terms "a spring pressure-probe," the extremity of which is so applied to the tympanic membrane as to press inwards the short process of the malleus. The movements are repeated several times in succession, and it is claimed that, in suitable cases, the rigidity of the chain of ossicles will be mechanically removed. According to Lucae, the treatment by means of the probe is adapted only for the cases in which Rinne's experiment gives negative results in connection with marked diminution of hearing for speech, and other symptoms of disease of the sound-conducting apparatus. The instrument is introduced in a direction parallel with the anterior superior wall of the meatus, and perpendicularly to the base of the short process, to which the ball of the probe is applied. From one to ten pressure-movements are then made in succession. Great care and gentleness are necessary, and in some cases this method of treatment is followed by slight temporary improvement. It has, however, the drawback of often causing severe pain, and the results as regards the hearing-power are sometimes decidedly mischievous. The effect on the subjective symptoms is similar to that produced by massage in like cases.†

Another plan, resembling massage in its action, is that devised by Hommel.‡ The tragus is pressed by the finger into the meatus and then allowed to return to its place, thus causing alternately condensation and rarefaction of the air in the canal.

---

* *Arch. f. Ohrenheilkunde*, xxi. 84.

† See a paper on Lucae's method by Dr. Eitelberg, *Archives of Otology*, xv. 36.

‡ *Arch. f. Ohrenheilkunde*, xxiii. 17.

The manipulations are repeated four or five times daily for about a minute and a half; the tragus is pressed inwards about 150 times on each occasion. It is claimed that in the early stages of the disease, in cases not benefited by the air-douche, these manipulations sometimes result in a decided improvement of the hearing. It is improbable that they act directly upon a rigid malleo-incudal articulation; but they may cause rhythmical movements of the membrane and prevent increase of rigidity and adhesions. No harm can result from practising Hommel's method; in some cases, it certainly relieves the subjective sensations.

The improvement which may be effected by the above described methods of treatment is rarely of a permanent character; after a time the hearing is apt to grow worse and the subjective sensations become aggravated. The advent of relapses may be delayed by short courses of treatment from time to time. Recourse should be had to the air-douche and injections, the method and remedy selected being determined by the amount of success previously experienced. It is well to recommend a course of treatment extending over three or four weeks, and repeated twice or three times a year, or even more frequently. In using instruments for condensing and rarefying the air in the meatus, there is always some risk of producing ecchymosis and even rupture of the membrane. Only a moderate degree of rarefaction should be caused, and the process should be devoid of pain.

The **Subjective Symptoms**, the noises in the ear, often cause much distress, and for their successful treatment it is all-important to discover the condition with which they are connected. Tinnitus is a common symptom in a large number of aural diseases, and therefore admits of no special treatment; it subsides with the disappearance of the original lesion, which may be situated in some part not directly connected with the ear. Thus there may be a primary or secondary affection of the labyrinth, a disease of the brain or of some cerebral nerve; and in these cases electricity may possibly be of service. On the other hand, there may be a history of syphilis or of debility the result of some other cachexia; and in such cases the sensation in the ear will probably be relieved by constitutional treatment. When there are no such indications, and when local measures fail to afford relief, recourse may be had to such remedies as chloral, the bromides, hydrobromic acid, iodide of potassium, and morphine. Narcotics are sometimes requisite in cases where the tinnitus prevents sleep. The relief obtained from any of these medicines is for the most part temporary. These subjective sensations will be again referred to in the chapters on Diseases of the Labyrinth.

As already mentioned, the Eustachian tubes are rarely normal in cases of adhesive inflammation of the tympanum. Their condition, however, varies; in some cases, the mucous membrane is swollen and relaxed, and the calibre is more or less narrowed, while in others, the condition is one of atrophy and the tubes are abnormally patent. For details of treatment the reader is referred to a previous chapter (see page 115). The employment of bougies for the purpose of dilating the tubes is not to be recommended. The author believes that this practice is fraught with serious risk, and that the result asserted to have been obtained, viz., restoration of patency, may be more safely achieved by the use of the air-douche and catheter and the injection of solutions.

In addition to local remedies, there are various general rules which should never be neglected in dealing with patients suffering from adhesive middle-ear catarrh. All details connected with the mode of life and condition of general health should be carefully attended to. Thus the patient should be protected, as far as possible, from all injurious influences, and especially from damp and cold, and from loud noises. His rooms should be well ventilated, and in bright dry weather plenty of exercise in the open air is likely to prove beneficial. The diet must be adapted to the state of the individual; alcoholic liquors and tobacco may be allowed in strict moderation to those accustomed to them, and this rule must be very carefully observed. Excessive mental strain and excitement are almost invariably mischievous, and must therefore be avoided as far as possible. The state of the skin should be attended to; a warm bath once or twice a week will prove beneficial. Cold bathing and the application of cold water to the head are to be avoided, except by strong and vigorous individuals with no tendency to catarrh.

Change of air and a prolonged residence in mountainous regions often have a good effect upon the course of adhesive catarrh. Politzer states that he has seen many cases thus ourse of local treatment ally indicated for weakly hange to a warmer climat for those who are prone The state of the patient making choice of a health sent to Carlsbad, Marienbad Bath, Buxton, or some one selected, while iron-springs are As a general rule, internal treat- as an adjunct to local measures of marked dyscrasia. When the administration of mercury or local treatment, and should be the remedies have been thoroughly

remains to describe various opera- the amelioration of the symptoms cases of this disease, no permanent local treatment; the ossicles become closed and incapable of movement. sensations are very prominent twenty years ago, Schwartze proposed excising the tympanic membrane cases thus treated, the subjective decidedly improved or altogether removed result was prevented by reproduction Many operations of this kind (fifty- cents) were subsequently performed by operation as free from danger, but no Another German surgeon, Kessel, showed membrane might be prevented by detach the posterior superior portion of th

Tympanic Membrane and Ossicles.—The indica are by no means clear. It cannot yield labyrinth be involved or if the stapes b fenestra ovalis. According to Bezold,* the characteristic of the latter condition lengthened bone-conduction for low tones; marked negative Rinne, and extensive defect in air-conduction at the lower end of the scale. If, however, there be only a certain amount of rigidity in the structures closing the fenestra, accompanied by an indrawn membrane and firm adhesions between the malleus and incus, the operation may be attended with more or less success. Removal of the membrane and of one or both of these bones will lessen the obstacles to the conduction of sound.

---

* *Otology*, 1896, vol. xxv. p. 69.

The details of the operation are as follows:—An incision through the membrane is made with a paracentesis knife at the middle of the lower border. A blunt-pointed knife is then passed through the opening thus made and carried upwards, first on one side and then on the other, to the highest point in the upper border, so as to effect complete separation from the *sulcus tympanicus*. At the posterior and upper part, the tendinous ring is likewise removed. After dividing the tendon of the tensor with a tenotome, and cutting through the malleo-incudal joint, the handle of the malleus, together with the membrane, is seized with a pair of forceps and carefully drawn out. The forceps should be applied as high up as possible; some authorities recommend that the removal should be effected by means of Wilde's polypus-snare. The incus is generally removed at the same time; if loosened from its attachment to the stapes, it will not interfere with sound-conduction. It may be detached, if necessary, by means of the snare. Sometimes the head of the malleus is firmly fixed to the roof of the tympanum; it is then advisable to cut through the adhesions with a synechotome, while the bone is held in the loop of the snare.

An operation, such as that above described, is practicable only when the calibre of the meatus is perfectly normal. General anæsthesia is always necessary; the operation requires some time for its performance, owing to the minuteness of the parts to be dealt with and the hæmorrhage which is liable to occur. Syringing should not be practised as a preliminary step, inasmuch as it always causes more or less hyperæmia of the membrane and internal portion of the meatus. A few minutes before the operation, the canal may be filled with warm sublimate solution (1 : 1,000), which is allowed to remain for a minute, and then removed. In spite of this precaution, and the employment of antiseptics after the operation, suppurative inflammation of the benefited after a lengthy but fruitless course of local treatment. A change to a hilly district is especially indicated for weakly, anæmic subjects. In cold weather, a change to a warmer climate is generally advisable, and particularly for those who are prone to suffer from naso-pharyngeal catarrh. The state of the patient's constitution should be considered in making choice of a health-resort. Gouty subjects should be sent to Carlsbad, Marienbad, Vichy, or Kissingen; for rheumatism, Bath, Buxton, or some one of the Continental Spas should be selected, while iron-springs are indicated for anæmic subjects. As a general rule, internal treatment of any kind is useful only as an adjunct to local measures, and for cases exhibiting evidences of marked dyscrasia. When there is a history of syphilis, the administration of mercury or iodine should be combined with local treatment, and should be perseveringly continued until the remedies have been thoroughly tried.

Operative Treatment.—It remains to describe various operations, having for their object the amelioration of the symptoms of adhesive catarrh. In many cases of this disease, no permanent improvement is effected by local treatment; the ossicles become more and more firmly ankylosed and incapable of movement, and deafness and subjective sensations are very prominent symptoms. More than twenty years ago, Schwartze proposed to relieve this condition by excising the tympanic membrane and the malleus. In some cases thus treated, the subjective symptoms were either decidedly improved or altogether removed; but the permanence of the result was prevented by reproduction of the tympanic membrane. Many operations of this kind (fifty-five on forty-seven patients) were subsequently performed by Lucae, who described the operation as free from danger, but not altogether satisfactory. Another German surgeon, Kessel, showed that regeneration of the membrane might be prevented by detaching the tendinous ring in the posterior superior portion of the circumference.

Excision of the Tympanic Membrane and Ossicles.—The indications for the operation are by no means clear. It cannot yield any good results if the labyrinth be involved or if the stapes be firmly adherent to the fenestra ovalis. According to Bezold,* the following symptoms are characteristic of the latter condition:

---

* *Archives of Otology*, 1896, vol. xxv. p. 69.

times. "A rigid enforcement of dietetic rules which almost, or quite, exclude meat, seems to lessen regenerative action." Dr. Sexton concluded his remarks by stating that the permanent removal of the membrana tympani requires for its success patience and gentleness in the necessary manipulations; but when this obstruction to the entrance of sound to the round window and base of the stapes is no longer present, deafness is removed; and where rigidity of the ossicles gives rise to tinnitus, etc., these phenomena also cease with the removal of the malleus or malleus and incus.

Artificial Perforation of the Tympanic Membrane.—Another plan of mitigating the results of chronic adhesive catarrh is to make a perforation in the tympanic membrane, and thus to provide a channel for the passage of sonorous undulations to the labyrinth. The establishment of a permanent opening in the membrane is, however, scarcely feasible. Politzer states that if this difficulty could be overcome, the operation would be indicated in the following cases: (1) When the membrana tympani is much thickened, and has lost its elasticity in consequence of calcareous deposits. (2) When the movements of the malleus and incus are prevented by adhesions between these bones and the walls of the tympanum. (3) When the Eustachian tube is the seat of irremediable strictures. (4) It might be tried, as a last resource, in cases of severe tinnitus which all other means have failed to relieve.

As a means of restoring the hearing-power, the operation is, of course, useless whenever the labyrinth is seriously affected, as shown by loss of osseous conduction. It is also unavailing when the stapes is firmly adherent, and when the membrane of the fenestra rotunda is either thickened or covered with calcareous deposit. For the operation to be successful, the footplate of the stapes and the membrane of the fenestra rotunda must be capable of a certain amount of mobility.

Methods of Operating.—Many plans have been proposed, but nearly all of them have fallen into disuse; the employment of the galvano-cautery offers the best chance of success. An aperture the size of a hemp-seed can be made in a second by the application of an ordinary button-ended point. A full-sized speculum must be previously passed into the auditory canal, and the membrane illuminated by the aid of a forehead mirror.

middle ear is a somewhat frequent result. W [illegible] come red
is much retracted, though still movable to so [illegible] closure to
to give a Politzer's inflation or inject air [illegible] membrane.
before the operation, in order to increase [illegible] ted to inflate
as much as possible. In order to gai [illegible] ssistant. The
authorities* have recommended prelimin [illegible] erwise a large
auricle and cartilaginous portion of the [illegible] pressure must
removal of the external wall of the [illegible] r easily penetrate
and posterior part of the osseous canal [illegible] inflammation of
be described in a subsequent chapter. [illegible] ct for making the

Excision of the Stapes is another oper [illegible] rane, because it is
and practised by Kessel. The nece [illegible] The steam which
however, be very difficult, and they [illegible] wn away as soon as
upon opening the labyrinth, *e.g.*, [illegible]
meningitis. It has also been propo [illegible] rtificial opening vary
to loosen the stapes† when firmly [illegible] no improvement as
posterior superior quadrant of the [illegible] subjective sensations:
excised, and through the opening [illegible] the stapes is immova-
probe is passed. The attempt is [illegible] has lost its elasticity
between the crura of the stapes, [illegible] of cases, more or less
directions. [illegible] change is seldom per-

Nearly all the surgeons wh [illegible] in the course of two
are fain to admit that the gen [illegible] ccur. This result has
It may well be doubted whe [illegible] preserve the patency o
justifiable while the indicati [illegible] ually successful. Politzer
fectly defined as they are [illegible] insertion of a vulcanit
to state that some aural [illegible] found, however, that in t
late Dr. Sexton,‡ of New [illegible] membrane showed sig
removal of the tympan [illegible] extended to the tympanu
ossicles in certain cases [illegible] the aperture sooner or la
forms of treatment [illegible]
disease. When there [illegible] would seem to show that it is lik
the two ears, Dr. S [illegible] than for remedial purpo
operation, which he [illegible] to more serious operatio
regeneration of th [illegible] ement, the question of rem
tissue should be [illegible] entertained. Possibly some met
possible. In som [illegible] perforation may yet be discover
[illegible] all attempts in that direction

[illegible] the **Posterior Fold** of the tympanic m

times. "A rigid enforcement of dietetic rules which almost, or quite, exclude meat, seems to lessen regenerative action." Dr. Sexton concluded his remarks by stating that the permanent removal of the membrana tympani requires for its success patience and gentleness in the necessary manipulations; but when this obstruction to the entrance of sound to the round window and base of the stapes is no longer present, deafness is removed; and where rigidity of the ossicles gives rise to tinnitus, etc., these phenomena also cease with the removal of the malleus or malleus and incus.

---

* Stacke, Arch
† Miot, Otol. C
‡ *Archives of*

Artificial Perforation of the Tympanic Membrane.—Another plan of mitigating the results of chronic adhesive catarrh is to make a perforation in the tympanic membrane, and thus to provide a channel for the passage of sonorous undulations to the labyrinth. The establishment of a permanent opening in the membrane is, however, scarcely feasible. Politzer states that if this difficulty could be overcome, the operation would be indicated in the following cases: (1) When the membrana tympani is much thickened, and has lost its elasticity in consequence of calcareous deposits. (2) When the movements of the malleus and incus are prevented by adhesions between these bones and the walls of the tympanum. (3) When the Eustachian tube is the seat of irremediable strictures. (4) It might be tried, as a last resource, in cases of severe tinnitus which all other means have failed to relieve.

As a means of restoring the hearing-power, the operation is, of course, useless whenever the labyrinth is seriously affected, as shown by loss of osseous conduction. It is also unavailing when the stapes is firmly adherent, and when the membrane of the fenestra rotunda is either thickened or covered with calcareous deposit. For the operation to be successful, the footplate of the stapes and the membrane of the fenestra rotunda must be capable of a certain amount of mobility.

Methods of Operating.—Many plans have been proposed, but nearly all of them have fallen into disuse; the employment of the galvano-cautery offers the best chance of success. An aperture the size of a hemp-seed can be made in a second by the application of an ordinary button-ended point. A full-sized speculum must be previously passed into the auditory canal, and the membrane illuminated by the aid of a forehead mirror.

Politzer emphasises the necessity for the point to become red hot at the moment the circuit is closed, and for the closure to be made immediately the cautery point touches the membrane. As a preliminary step the patient should be directed to inflate his ears, or the air-douche is employed by an assistant. The cauterisation should be only momentary, for otherwise a large portion of the membrane may be destroyed. No pressure must be employed, as the point of the instrument might easily penetrate to the inner wall of the tympanum, and set up inflammation of the mucous membrane. The most suitable spot for making the opening is the inferior portion of the membrane, because it is at the greatest distance from the inner wall. The steam which is evolved during the operation must be blown away as soon as possible.

The effects of the production of an artificial opening vary in different cases. There may be little or no improvement as regards either the hearing-power or the subjective sensations; and in such cases it may be inferred that the stapes is immovaably fixed, and that the fenestra rotunda has lost its elasticity. On the other hand, in a fair proportion of cases, more or less improvement is experienced; though the change is seldom permanent, for the opening generally closes in the course of two or three weeks, and the symptoms recur. This result has caused many attempts to be made to preserve the patency of the opening; but none have been really successful. Politzer, some twenty years ago, suggested the insertion of a vulcanite eyelet into the opening. It was found, however, that in the course of a few days or weeks the membrane showed signs of purulent inflammation, which extended to the tympanum. The eyelet was thus expelled, and the aperture sooner or later closed by cicatrisation.

The results of this method would seem to show that it is likely to prove useful rather for diagnostic than for remedial purposes. It might be tried as a preliminary to more serious operations: if followed by some degree of improvement, the question of removing the membrane might be entertained. Possibly some method of keeping open an artificial perforation may yet be discovered; but up to the present time all attempts in that direction have resulted in failure.

An Incision through the Posterior Fold of the tympanic membrane is another method of treating certain conditions of this structure. A brief account of the operation has been given in a previous chapter (see page 365). It is sometimes performed in cases of adhesive catarrh, with the object of relieving tension of the membrane, thereby improving the hearing-power and lessening the subjective sensations. As necessary conditions for its success, the Eustachian tube must be patent, and there must be no accumulation of secretion in the tympanum; absence of adhesions between the membrane and the wall of the labyrinth and comparative soundness of the nervous structures must likewise be demonstrated. The operation was suggested by Politzer in 1871. It is indicated in cases in which the membrane is much drawn inwards, and where the lower extremity of the handle of the malleus appears to be displaced in a direction inwards and backwards, while the short process and the posterior fold project towards the external meatus. Under these conditions the membrane is generally indurated and but little sensitive, and is therefore far more suitable for incision than when in an hyperæmic and swollen state. As a matter of course, ordinary treatment should first be tried, and if no relief be obtained, recourse may be had to this operation, under the conditions already specified.

The operation (see page 365) consists in dividing the posterior fold perpendicularly, either from above downwards or in the opposite direction, the most suitable spot being immediately behind the short process, but the incision may be made midway between this and the peripheral end of the fold. The division is generally accompanied by a grating sound; the wound in the membrane gapes, and the handle of the malleus assumes a more normal position. Hæmorrhage is generally slight, and can be easily arrested.

There is some risk of injuring the chorda tympani nerve, though Lucae states that, in 140 cases in which he performed the operation, he never witnessed any symptoms of this accident. If, however, the nerve be cut through, the ends generally unite in the course of a few weeks, and its function is restored. If the fold be divided nearer to the periphery, there is some risk of injuring the long process of the incus, and the articulation with the stapes. The general result of the operation is to diminish the severity of the subjective symptoms; but the improvement is in most cases transitory, though it may last for several weeks. Sometimes the hearing-power is slightly increased.

Division of the Anterior Ligament of the Malleus is another operation devised and performed by Politzer,* with the view of improving the hearing-power, and lessening the subjective sensations, in cases in which this band is contracted and abnormally adherent. Under such circumstances, the membrane is much drawn inwards, and the air-douche causes a considerable improvement, which soon passes off. In the performance of this operation, an incision 1½mm. long is made in the membrane, immediately in front of the short process of the malleus, and directed from above downwards. Through the opening thus made, the surgeon passes a small knife bent at a right angle near its extremity, pushes it under the upper border of the membrane, and cuts outwards and downwards through the anterior ligament and the long process of the malleus. A grating sound is heard as these parts are divided.

Multiple Incisions into the Membrane.—In cases of extreme tension of the membrana tympani, as a result of pathological changes in its tissue, Gruber † recommends multiple incisions. The wounds of course heal, but this process should be retarded as much as possible by the frequent employment of the air-douche in the after-treatment. Gruber makes four, five, or more incisions, and unites them by cross-cuts at right angles. As a general rule, the chief incisions are made from the malleus towards the periphery; but their position should be modified according to the conditions of each case. Before resorting to the operation, it is necessary to ascertain the condition of the labyrinth, and the following is the method recommended by Gruber. He first alludes to the fact that a vibrating tuning-fork held in front of the ear is not so well heard when Valsalva's method is being practised, as it is before and after, the increased tension of the membrane lessening the conduction of sound. On the other hand, under similar circumstances, a tuning-fork applied to the head is better heard.

Deviations from these rules are of diagnostic importance. When the membrane is unduly relaxed, Valsalva's experiment causes the tuning-fork held in front of the ear to be better heard, but osseous conduction is diminished. In cases of abnormal tension, the experiment either makes no alteration in the sound of the fork in the first position, or causes it to be less distinctly heard. The sound of the fork placed on the head is likewise not altered unless the tension be increased, in which case it is more distinctly heard.

---

* *Lehrbuch der Ohrenheilkunde*, S. 259.

† *Lehrbuch der Ohrenheilkunde*, S. 549.

In this method of examination, the patient's statements serve as a test of each other. For example, if a patient, with a relaxed membrane, asserts that a vibrating tuning-fork in front of the ear is heard better during Valsalva's experiment than either before or after it, he ought to hear the sound less distinctly when the fork is placed on the head during inflation.

Absolutely correct inferences cannot, however, be always drawn from the results of Valsalva's experiment when employed for purposes of diagnosis as above described. Thus when the membrane is abnormally relaxed, Valsalva's experiment may cause an undue degree of tension, and the vibrating tuning-fork held in front of the ear will be less distinctly heard, whereas an improvement will be noticed when the air is driven into the tympanum with only slight force. Besides, it is quite possible that when Valsalva's method is practised, other structures in the ear may be so affected that the hearing-power is improved irrespective of any change in the membrana tympani. The fact is that this method of diagnosis must be taken in conjunction with others; agreement in results serves to determine the nature of the case.

The after-treatment consists in carefully removing any blood which may have escaped and applying iodoform gauze. A few days afterwards the air-douche should be employed, and this should be continued every other day for some time after the incisions have healed. If inflammation be set up, it must be treated in the manner described in a previous chapter. Such a complication is, however, very rare.

Gruber, in opposition to Politzer, asserts that the cicatrisation of incisions in the membrane does not increase its tension, and that multiple incisions are not suitable for cases in which its tissue is atrophied and relaxed. After incision, union generally takes place by first intention, without any secondary changes; in other cases a cicatrix forms, the appearance of which indicates middle ear is a somewhat frequent result. When the membrane is much retracted, though still movable to some extent, it is well to give a Politzer's inflation or inject air through a catheter before the operation, in order to increase the tympanic space as much as possible. In order to gain more room, some authorities* have recommended preliminary detachment of the auricle and cartilaginous portion of the meatus, followed by the removal of the external wall of the attic, and of the upper and posterior part of the osseous canal. These operations will be described in a subsequent chapter.

Excision of the Stapes is another operation which was suggested and practised by Kessel. The necessary manipulations must, however, be very difficult, and they involve the risks attendant upon opening the labyrinth, *e.g.*, purulent internal otitis and meningitis. It has also been proposed, as a less serious operation, to loosen the stapes† when firmly adherent to the fenestra. The posterior superior quadrant of the tympanic membrane is partially excised, and through the opening thus made a small hook or bent probe is passed. The attempt is then made to pass the instrument between the crura of the stapes, and to move the bone in various directions.

Nearly all the surgeons who have performed these operations are fain to admit that the general results are far from satisfactory. It may well be doubted whether such severe measures are really justifiable while the indications for their adoption are so imperfectly defined as they are at present. It is only fair, however, to state that some aural surgeons of repute, and notably the late Dr. Sexton,‡ of New York, have recommended and practised removal of the tympanic membrane with one or more of the ossicles in certain cases of progressive sclerosis, in which other forms of treatment have failed to arrest the advance of the disease. When there is a difference in the hearing-power of the two ears, Dr. Sexton usually chose the worse ear for the operation, which he regarded as entirely free from danger. If regeneration of the membrane take place, the newly-formed tissue should be carefully cut away with as little irritation as possible. In some cases, this operation has to be repeated several

times. "A rigid enforcement of dietetic rules which almost, or quite, exclude meat, seems to lessen regenerative action." Dr. Sexton concluded his remarks by stating that the permanent removal of the membrana tympani requires for its success patience and gentleness in the necessary manipulations; but when this obstruction to the entrance of sound to the round window and base of the stapes is no longer present, deafness is removed; and where rigidity of the ossicles gives rise to tinnitus, etc., these phenomena also cease with the removal of the malleus or malleus and incus.

---

* Stacke, *Archiv f. Ohrenheilkunde*, vol. xxxi. p. 201.

† Miot, Otol. Congress, Paris, 1889; *Archiv f. Ohrenheilkunde*, vol. xxix. p. 306.

‡ *Archives of Otology*, vol. xx. p. 95.

Artificial Perforation of the Tympanic Membrane.—Another plan of mitigating the results of chronic adhesive catarrh is to make a perforation in the tympanic membrane, and thus to provide a channel for the passage of sonorous undulations to the labyrinth. The establishment of a permanent opening in the membrane is, however, scarcely feasible. Politzer states that if this difficulty could be overcome, the operation would be indicated in the following cases: (1) When the membrana tympani is much thickened, and has lost its elasticity in consequence of calcareous deposits. (2) When the movements of the malleus and incus are prevented by adhesions between these bones and the walls of the tympanum. (3) When the Eustachian tube is the seat of irremediable strictures. (4) It might be tried, as a last resource, in cases of severe tinnitus which all other means have failed to relieve.

As a means of restoring the hearing-power, the operation is, of course, useless whenever the labyrinth is seriously affected, as shown by loss of osseous conduction. It is also unavailing when the stapes is firmly adherent, and when the membrane of the fenestra rotunda is either thickened or covered with calcareous deposit. For the operation to be successful, the footplate of the stapes and the membrane of the fenestra rotunda must be capable of a certain amount of mobility.

Methods of Operating.—Many plans have been proposed, but nearly all of them have fallen into disuse; the employment of the galvano-cautery offers the best chance of success. An aperture the size of a hemp-seed can be made in a second by the application of an ordinary button-ended point. A full-sized speculum must be previously passed into the auditory canal, and the membrane illuminated by the aid of a forehead mirror.

Politzer emphasises the necessity for the point to become red hot at the moment the circuit is closed, and for the closure to be made immediately the cautery point touches the membrane. As a preliminary step the patient should be directed to inflate his ears, or the air-douche is employed by an assistant. The cauterisation should be only momentary, for otherwise a large portion of the membrane may be destroyed. No pressure must be employed, as the point of the instrument might easily penetrate to the inner wall of the tympanum, and set up inflammation of the mucous membrane. The most suitable spot for making the opening is the inferior portion of the membrane, because it is at the greatest distance from the inner wall. The steam which is evolved during the operation must be blown away as soon as possible.

The effects of the production of an artificial opening vary in different cases. There may be little or no improvement as regards either the hearing-power or the subjective sensations; and in such cases it may be inferred that the stapes is immovably fixed, and that the fenestra rotunda has lost its elasticity. On the other hand, in a fair proportion of cases, more or less improvement is experienced; though the change is seldom permanent, for the opening generally closes in the course of two or three weeks, and the symptoms recur. This result has caused many attempts to be made to preserve the patency of the opening; but none have been really successful. Politzer, some twenty years ago, suggested the insertion of a vulcanite eyelet into the opening. It was found, however, that in the course of a few days or weeks the membrane showed signs of purulent inflammation, which extended to the tympanum. The eyelet was thus expelled, and the aperture sooner or later closed by cicatrisation.

The results of this method would seem to show that it is likely to prove useful rather for diagnostic than for remedial purposes. It might be tried as a preliminary to more serious operations: if followed by some degree of improvement, the question of removing the membrane might be entertained. Possibly some method of keeping open an artificial perforation may yet be discovered; but up to the present time all attempts in that direction have resulted in failure.

An Incision through the Posterior Fold of the tympanic membrane is another method of treating certain conditions of this structure. A brief account of the operation has been given in a previous chapter (see page 365). It is sometimes performed in cases of adhesive catarrh, with the object of relieving tension of the membrane, thereby improving the hearing-power and lessening the subjective sensations. As necessary conditions for its success, the Eustachian tube must be patent, and there must be no accumulation of secretion in the tympanum; absence of adhesions between the membrane and the wall of the labyrinth and comparative soundness of the nervous structures must likewise be demonstrated. The operation was suggested by Politzer in 1871. It is indicated in cases in which the membrane is much drawn inwards, and where the lower extremity of the handle of the malleus appears to be displaced in a direction inwards and backwards, while the short process and the posterior fold project towards the external meatus. Under these conditions the membrane is generally indurated and but little sensitive, and is therefore far more suitable for incision than when in an hyperæmic and swollen state. As a matter of course, ordinary treatment should first be tried, and if no relief be obtained, recourse may be had to this operation, under the conditions already specified.

The operation (see page 365) consists in dividing the posterior fold perpendicularly, either from above downwards or in the opposite direction, the most suitable spot being immediately behind the short process, but the incision may be made midway between this and the peripheral end of the fold. The division is generally accompanied by a grating sound; the wound in the membrane gapes, and the handle of the malleus assumes a more normal position. Hæmorrhage is generally slight, and can be easily arrested.

There is some risk of injuring the chorda tympani nerve, though Lucae states that, in 140 cases in which he performed the operation, he never witnessed any symptoms of this accident. If, however, the nerve be cut through, the ends generally unite in the course of a few weeks, and its function is restored. If the fold be divided nearer to the periphery, there is some risk of injuring the long process of the incus, and the articulation with the stapes. The general result of the operation is to diminish the severity of the subjective symptoms; but the improvement in most cases transitory, though it may last for several weeks. Sometimes the hearing-power is slightly increased.

Division of the Anterior Ligament of the Malleus is another operation devised and performed by Politzer,* with the view of improving the hearing-power, and lessening the subjective sensations, in cases in which this band is contracted and abnormally adherent. Under such circumstances, the membrane is much drawn inwards, and the air-douche causes a considerable improvement, which soon passes off. In the performance of this operation, an incision 1½mm. long is made in the membrane, immediately in front of the short process of the malleus, and directed from above downwards. Through the opening thus made, the surgeon passes a small knife bent at a right angle near its extremity, pushes it under the upper border of the membrane, and cuts outwards and downwards through the anterior ligament and the long process of the malleus. A grating sound is heard as these parts are divided.

Multiple Incisions into the Membrane.—In cases of extreme tension of the membrana tympani, as a result of pathological changes in its tissue, Gruber † recommends multiple incisions. The wounds of course heal, but this process should be retarded as much as possible by the frequent employment of the air-douche in the after-treatment. Gruber makes four, five, or more incisions, and unites them by cross-cuts at right angles. As a general rule, the chief incisions are made from the malleus towards the periphery; but their position should be modified according to the conditions of each case. Before resorting to the operation, it is necessary to ascertain the condition of the labyrinth, and the following is the method recommended by Gruber. He first alludes to the fact that a vibrating tuning-fork held in front of the ear is not so well heard when Valsalva's method is being practised, as it is before and after, the increased tension of the membrane lessening the conduction of sound. On the other hand, under similar circumstances, a tuning-fork applied to the head is better heard.

Deviations from these rules are of diagnostic importance. When the membrane is unduly relaxed, Valsalva's experiment causes the tuning-fork held in front of the ear to be better heard, but osseous conduction is diminished. In cases of abnormal tension, the experiment either makes no alteration in the sound of the fork in the first position, or causes it to be less distinctly heard. The sound of the fork placed on the head is likewise not altered unless the tension be increased, in which case it is more distinctly heard.

---

* *Lehrbuch der Ohrenheilkunde*, S. 259.

† *Lehrbuch der Ohrenheilkunde*, S. 549.

In this method of examination, the patient's statements serve as a test of each other. For example, if a patient, with a relaxed membrane, asserts that a vibrating tuning-fork in front of the ear is heard better during Valsalva's experiment than either before or after it, he ought to hear the sound less distinctly when the fork is placed on the head during inflation.

Absolutely correct inferences cannot, however, be always drawn from the results of Valsalva's experiment when employed for purposes of diagnosis as above described. Thus when the membrane is abnormally relaxed, Valsalva's experiment may cause an undue degree of tension, and the vibrating tuning-fork held in front of the ear will be less distinctly heard, whereas an improvement will be noticed when the air is driven into the tympanum with only slight force. Besides, it is quite possible that when Valsalva's method is practised, other structures in the ear may be so affected that the hearing-power is improved irrespective of any change in the membrana tympani. The fact is that this method of diagnosis must be taken in conjunction with others; agreement in results serves to determine the nature of the case.

The after-treatment consists in carefully removing any blood which may have escaped and applying iodoform gauze. A few days afterwards the air-douche should be employed, and this should be continued every other day for some time after the incisions have healed. If inflammation be set up, it must be treated in the manner described in a previous chapter. Such a complication is, however, very rare.

Gruber, in opposition to Politzer, asserts that the cicatrisation of incisions in the membrane does not increase its tension, and that multiple incisions are not suitable for cases in which its tissue is atrophied and relaxed. After incision, union generally takes place by first intention, without any secondary changes; in other cases a cicatrix forms, the appearance of which indicates that the tension of the membrane would be lessened by the formation of several cicatrices.

Division of the Tendon of the Tensor Tympani muscle is another method of treatment which has been recommended for adoption. It was first performed on the living subject by Weber-Liel in 1868. Abnormal contraction and shortening of the tendon produces excessive tension of the membrana tympani and of the joints of the ossicles, and increases the pressure in the labyrinth. This condition of the tendon is not peculiar to adhesive inflammation; it is often associated with suppuration in the middle ear with perforation and retraction of the membrane. The object of dividing the tendon is to relieve the tension and the symptoms which it causes. A satisfactory result is attainable only when other serious pathological changes are presumably absent from the middle ear and labyrinth.

There are no positive signs clearly indicative of contraction of the tendon. An indrawn condition of the membrane is always associated with it; but may be produced by other changes of common occurrence, *e.g.*, occlusion of the Eustachian tube, atrophy of the tympanic membrane, and adhesions to deeper parts in the cavity. It has been supposed that improvement of hearing after the use of the air-douche and lessening of subjective sensations after the rarefaction of air in the meatus point to contraction of the tendon. Such changes, however, are just as likely to result from relaxation of ossicular tension, stretching of bands of false membrane, etc. It is sometimes stated that contraction of the tendon may be inferred to exist when the handle of the malleus is not only drawn inwards (and, therefore, seems shortened when viewed from the meatus), but also made to revolve slightly on its long axis, so that it appears to be broader than usual. This change is due to the mode in which the tendon of the tensor is inserted into the handle of the malleus. It has, however, been shown by Urbantschitsch* that the place of insertion varies considerably, and it may well be doubted whether contraction of the tendon always causes the handle of the malleus to revolve on its long axis. Some persons are able to cause voluntary contraction of the tensor tympani, and they find that low notes are then less distinctly heard, and that a humming-sound is perceived. It remains to be seen whether this fact can be utilised for purposes of diagnosis.

---

* *Lehrbuch der Ohrenheilkunde*, Aufl. III. S. 233.

Gruber * thinks that contraction of the tendon is an indication for tenotomy, provided that the subjective sensations are relieved by the use of the catheter. He believes that the subsequent union of the divided ends does not tend to increase the contraction, but rather has a contrary effect. Tenotomy is found to be beneficial when simple paracentesis of the membrane has proved useless.

Kessel † lays down the following indications for performing tenotomy of the tensor:—

1. Paralysis of the stapedius muscle with unrestrained action of the tensor.

2. Permanent spasm of the tensor.

3. Perforations involving the "cone of light," and when the openings are reniform or heart-shaped.

4. In catarrh with swelling, so long as the stapes is movable, and excessive pressure in the labyrinth admits of diminution. Also, when the sounds are continuous, and the excessive pressure in the labyrinth is obviously dependent upon changes in the internal muscles of the ear.

The late Dr. Sexton,‡ of New York, warmly advocated tenotomy of the tensor in cases of sclerosis with relatively good bone-conduction, and thought that the operation often improved the functions of the intra-tympanic and muscular apparatus for the perception of sound, words, and speech. The indications, he stated, were as follows:—

1. Progressive deafness, with neuropathic sclerosis; the operation, however, is not likely to be successful unless one-fourth of the normal duration of perception is still preserved.

2. The operation should be performed on the worse ear if a positive result of Weber's and a negative of Rinne's experiment make us suspect permanent obstacles to conduction in this ear, while there is no trace of this condition in the better ear.

3. If one ear be quite deaf, and the other becoming so, the operation should be performed upon the latter, on the ground

---

* *Lehrbuch der Ohrenheilkunde*, 2 Aufl. S. 562.

† *Arch. f. Ohrenheilkunde*, vol. xxxi. S. 238.

‡ *Archives of Otology*, vol. xix. p. 151.

that reduction of tension of the muscular apparatus on one side will benefit that of the other.

Method of Operating.—In the normal condition, the exposed portion of the tendon is only 2mm. in length, and, when the membrane is considerably indrawn, the space for the incision is very limited. As a general rule, it should be made just behind the handle of the malleus, but the exact spot must depend upon the circumstances of the case. The steps of the operation are as follows:—A paracentesis knife is used to make an incision 1mm. behind and parallel with the handle of the malleus. A tenotome, adapted to the side to be operated upon, is passed through the opening with its rounded point turned upwards and forwards towards the roof of the tympanum, until it touches the head of the malleus or the malleo-incudal articulation. The instrument is then turned at a right angle, so that its edge is brought immediately above the tendon, which is then divided by drawing the knife backwards and forwards, and from above downwards; a grating noise is audible as the resistance is felt to be overcome. By drawing out the handle of the malleus with the tenotome, the operator can determine whether the tendon is completely divided. The hæmorrhage is usually slight. If, after complete division of the tendon, the handle of the malleus retain its former position, adhesions in the tympanum may be inferred to exist.

In so-called neuropathic sclerosis, the tympanic membrane is always far less sensitive than usual; but, during the operation, it is generally advisable to use local or general anæsthetics. Dr. Sexton recommended a little ether on absorbent cotton-wool, to be placed upon the membrane and left to evaporate. He advised that the incision should be made *in front* of the short process. The difficulties of the operation are increased by narrowness of the meatus, great retraction of the membrane, and by adhesions between it and the labyrinth. After the operation, the patient should remain in bed, and powdered boric acid on cotton-wool should be kept in the ear. The wound usually heals by first intention in the course of a few days. Any blood effused into the tympanum is more or less rapidly absorbed. If there be symptoms of otitis, the ordinary treatment must be adopted. When the wound in the membrane has quite healed, it is well to inject air through a catheter every second or third day, or to rarefy the air in the meatus.

Gruber directs that when the incision is to be made behind the handle of the malleus, the concavity of the tenotome is to be directed forwards; and in the opposite direction when the spot chosen for the incision is in front of that process of bone, on a level with the upper third of which the knife is passed through the membrane. When the tympanum is reached, the concave surface of the tenotome is applied to the handle of the malleus, and an incision parallel with it is made upwards so as to divide the tendon which runs obliquely from within outwards through the tympanum. When the instrument is introduced behind the malleus, its point should be carried forwards to a corresponding extent, so as to be certain of dividing the tendon, which is sometimes considerably in front of its ordinary position. Care must be taken to give to the edge of the tenotome a somewhat lateral direction by turning the point slightly upwards, so as to avoid the wall of the carotid canal. Gruber states that the direction and form of the external meatus must determine the spot for the incision in the membrane. As a general rule, this should be made in front of the malleus; but in many cases the convexity of the anterior wall of the meatus is very marked, and hides the anterior segment of the membrane, so that the portion behind the malleus must be selected.

The **Results of the Operation** vary considerably in different cases; the subjective symptoms are sometimes much improved, the tinnitus ceases or becomes less troublesome, and the giddiness has been known to disappear. The effects upon the hearing-power are far less marked, and in not a few cases no improvement is perceptible. According to some authorities, any good results which may be noticed are due to the incision in the membrane. The condition of the patients several weeks or months after the operation is the best test of its value. Aggravation of all the symptoms has been observed in a few cases, and severe suppurative inflammation has been known to follow. Politzer asserts that all trustworthy accounts are of an unfavourable character. With few exceptions, any improvement in the hearing-power completely subsides, while the subjective sensations recur and even become more troublesome. In several patients who came to him some months after the operation had been performed, there was complete deafness on that side, the condition having rapidly become worse since the operation.

Division of the tendon is, therefore, an operation of a very doubtful benefit; any advantage is but slight, and its results are not infrequently mischievous. It may prove beneficial in some cases; but positive indications for its performance have not as yet been discovered.*

The author's opinion as to the value and expediency of operative interference in the cases under consideration has been sufficiently indicated in the foregoing pages. In explanation of the fact that all treatment is often unavailing, it is only fair to urge that the large majority of patients do not come under observation until the disease has reached an advanced stage, and serious changes have taken place in the structures within the tympanum. The delicate tissue covering the inner aspect of the tympanic membrane, the ossicles, and the fenestræ, becomes converted into stiff unyielding layers of firm connective tissue, often more or less calcified. The normal mobility of the chain of ossicles is impaired, or even quite abolished by the rigid adhesions formed between various parts; and when these changes have reached their acme, it is easy to understand why any method of treatment so often fails either to improve the hearing-power, or to relieve the subjective sensations. But by proper treatment in the earliest stages, much might be done to preserve the mobility of the sound-conducting apparatus. The medical attendants of families in which such cases have occurred should pay particular attention to any symptoms pointing in the same direction, among other members, and should urgently recommend appropriate treatment or the aid of a specialist.

---

* In the *Practitioner* for May, 1897, Mr. A. H. Cheatle has given an excellent summary of the opinions held by many aurists with regard to operative interference in chronic non-suppurative middle-ear disease.

CHAPTER XXVII.

ACUTE SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR.

Nature of the Disease—Causes—Micro-Organisms—Frequency as affected by Age, Sex, Climate, etc.—Reasons for Frequency in Young Subjects—Symptoms: Subjective, as Pain, Impairment of Hearing, etc.; Objective, Changes in Tympanic Membrane—Perforation, Signs of, and Methods of Discovering—Character of Secretion—Course and Results—Diagnosis—Prognosis—Treatment—Antiphlogistics—Paracentesis—The Air-Douche—Local Remedies—Treatment of Cases of Spontaneous Perforation—Mastoid Complications.

Acute Suppurative Inflammation of the tympanum may come on suddenly, without any previous local symptoms, or may follow an attack of catarrhal inflammation of the cavity. It is characterised by rapid effusion of purulent fluid, hyperæmia and swelling of the lining membrane, and by inflammation of the membrana tympani, which often becomes perforated. The opening shows a marked tendency to become closed, whereby the condition is distinguished from the chronic form. The pus is formed either on the surface of the mucous membrane or within its substance, and sometimes between it and the bone. More or less marked destruction of the tissues is the almost invariable result, and in severe cases the process extends to the bony walls. The inflammation likewise spreads to the Eustachian tube, and often backwards to the mastoid cells, which contain purulent or sero-purulent exudation. The labyrinth may become involved, but is seldom seriously affected; hyperæmia and serous exudation are the ordinary changes.

Causes.—These are generally the same as those of ordinary catarrhal inflammation; but micro-organisms would seem to play ery important part in the causation of suppurative inflamman. The channels by which they may gain access to the tymnum have been already described (see page 341). Zaufal's earches* show that organisms of the following kinds have n found in the middle ear in cases of suppurative inflamtion: the pneumonia-bacillus of Friedländer; the diplococcus umoniæ; the streptococcus pyogenes, staphylococcus pyo [illegible] nes albus, pyogenes aureus, cereus albus and tenuis; bacill [illegible] cyaneus; micrococcus tetragenus and saccharomyces albica [illegible] rious kinds of micro-organisms often appear in successi [illegible] set preparing the way for another, and thus maintaining [illegible] purative process. In the primary form of suppurative o [illegible] tion, the diplococcus pneumoniæ very often occurs; in secon [illegible] ms, the streptococcus pyogenes is more common. Rohr [illegible] es that the non-fœtid secretions contain only cocci; wh [illegible] lli are abundant and cocci comparatively few in fœtid [illegible] rges. Streptococci would seem to indicate a severe [illegible] inflammation, and the probability of extension to the ma [illegible] n.

Whether micro-organisms are essential to the developme [illegible] puration within the tympanum is not as yet definitely se [illegible] aural complaint is, however, often secondary to acut [illegible] nic inflammatory processes in the naso-pharynx, and [illegible] these disorders are associated with a profuse developm [illegible] ro-organisms. It is a not infrequent complication of [illegible] ctious diseases, e.g., scarlet fever, measles, small-pox, [illegible] ria, typhus and typhoid fevers, influenza, tuberculosis, s [illegible] sipelas, and puerperal affections. With regard to scarl [illegible] measles, it would appear that aural complications [illegible] quent during some epidemics, and rare in others. [illegible] es of cases of scarlet fever cited by Bu [illegible] ckhardt- [illegible] per cent. of the patients suffered from middle-ear [illegible] in another, the proportion was 22 per cent. [illegible] puration is sometimes attributable to exposure to c [illegible] ries of various kinds, as blows on the ea [illegible] r, falls on the [illegible] to the p [illegible] operations on the membrana tympa [illegible] i; to the efforts m [illegible] foreign bodies in the meatus, and to [illegible] the

---

[illegible] Ohrenheilkunde, vol. xxxi. p. 180.

[illegible] der Bakterien des Ohres und des [illegible] Nasen-Rachenraumes, Volkmann's Sammlung Klin. Vorträge, No. 182.

n spring and autum
s are equally liable to
heat, cold, and moistur
upon its development
of all cases, the proportion
States as in Germany. The
per cent.); but when
th ears are liable to be

in children is favoured by
the special liability of young
to severe affections of the nose
ms of pneumonia. Congenital
disease. Some authorities con-
suppurative inflammation of the
ation of the peripheral branches
d to the vagus and glosso-pharyn-
disorder, with inflammation as a
be correct or not, it is probable
the occurrence of inflammation in
the hyperæmia and swelling which
gressive metamorphosis of the mucous
added, according to Urbantschitsch,
into the tympanum during futile
the contents of the stomach during

ctious fevers as a cause of middle-ear
membered that the deafness so common
ther to nervous disorder or to catarrhal
on of the tympanum. In the early
impairment of hearing ordinarily results
ease.
mplaint, viz., relapsing fever, which is
anied by middle-ear inflammation. In an
ended by Dr. Luchthau,* aural complica-
180 out of 300 patients, the majority
nt inflammation of the tympanum. Addi-
regard to the connection between various

---

erkrankungen bei Febris Recurrens. Virch. Arch., and to the effects of caustic

inflammation results from the
chian tube, as sometimes occurs
r's douche. Plugging the pos-
to set up inflammation of the
sses along the tube and acts as
oses pharyngitis, which extends in
ive inflammation of the middle ear
moval of adenoid growths. In such
itation caused by blood lodging
the extension of inflammation
m. Some years ago the author
and forty years of age, suffering
n of the middle ear, which came
val of a tonsil with the ordinary
ve been placed on record in which
ds have passed along the Eustachian
ne tympanum. In one such instance,
nite catheter became detached, and found
middle ear, causing acute inflammation, for
h the membrana tympani was incised. The
removed through the opening, and the case
ctorily. In another case, recorded by Urbant-
oat-spikelet passed from the pharynx along the
used suppurative inflammation in the tympanum.
lowed by circumscribed inflammation in the external
h polypoid growths. After a time, the foreign body
rough a perforation in the membrana tympani, and
toms then subsided.

few rare cases, suppurative inflammation of the tympanum
ulted from purulent formations within the cranium. The
nds its way into the tympanum through some fissure or
in the temporal bone, and causes inflammation of the cavity
perforation of the membrane. Caries of the osseous roof may
another step in the process; an opening results, through which
e pus enters the tympanum.

Suppurative inflammation of the middle ear is more common
dults than in children (in the proportion of 58·6 : 41·4

---

* *Lehrbuch der Ohrenheilkunde*, 3 Aufl. S. 202.

experienced. There is nothing characteristic about these phenomena; they are also met with in catarrhal inflammation, and they are by no means constant in the purulent form of the complaint. They are due in part to increase of pressure, and in part to hyperæmia of the labyrinth and serous exudation ; their character is apt to become modified during the progress of the disease. The noises in the ears are variously described as "roaring," "singing," "hissing," "throbbing," etc. The degree in which the hearing is impaired varies considerably. Some difference can always be detected, and before perforation has taken place it is often very marked; but owing to the severity of the other symptoms, it may not be fully recognised. The deafness is generally proportionate to the amount of exudation, the swelling of the mucous membrane, the height of the fever, and the condition of the sensorium. It is likely to be complete if the labyrinth be seriously involved. As a general rule bone-conduction is preserved; in the early stages and before perforation has occurred it is often increased. According to Politzer, however, in scarlatinous, diphtheritic, and syphilitic cases, bone-conduction is often considerably impaired, or even altogether lost.

In children all the symptoms are wont to assume a severe type; but in adults they are not infrequently much less prominent. In these latter there is often no disorder of the sensorium; but a high temperature, a very rapid pulse, and a sensation of fulness in the head are sometimes very marked. On the other hand, in cases due to tuberculosis there may be neither pain nor any particular disturbance of the general system; the process goes on insidiously, and increase of moisture in the meatus or discharge of purulent matter therefrom is the first indication of mischief. It must be remembered that symptoms of pyæmia sometimes become developed in the course of suppurative inflammation of the middle ear, and without sinus-thrombosis as a preliminary. The pyæmia is due to osteophlebitis, and is more frequently associated with acute suppurative otitis than with the chronic form.

The **Objective Symptoms** consist mainly of changes in the condition of the membrana tympani and of evidences of irritation in the meatus and surrounding parts. The glands in the neighbourhood of the ear are often more or less swollen, and, when the mastoid cells are involved, the soft parts covering that process are apt to become swollen and reddened. The cartilaginous portion of the meatus is similarly affected, while the lining of the osseous portion is still more decidedly inflamed.

The internal or mucous layer of the membrana tympani, being continuous with the lining membrane of the cavity, participates in the inflammation, and the process extends to the other layers. The membrane is at first reddened and swollen, and soon loses its lustre; as the hyperæmia increases, it becomes more convex externally, and yellowish-red or bluish-red in appearance. Owing to the redness and swelling of the deep portion of the meatus, the circumference of the membrane is not clearly defined. There is marked injection of the vessels near the handle of the malleus; and later on, this part of the bone is often hidden by the swollen membrane, while a yellowish point indicates the position of the short process. When the exudation is profuse, the position of the handle of the malleus is marked by a furrow, on each side of which the membrane bulges out towards the meatus. The posterior portion is especially prominent; the epidermis often becomes detached at various spots, and the whole surface of the membrane is sometimes dotted over with little points, which more or less clearly reflect the light from the mirror. Ecchymoses, and the formation of minute abscesses between the layers, are sometimes noticed. Perforation occurs from the bursting of one or more abscesses, or from extension of ulceration. The opening is usually in the lower half of the membrane; and in three-fourths of the cases, in the anterior inferior quadrant. Bezold asserts that perforation is most common in the posterior inferior quadrant. Illustrations of various forms of perforation will be found in a subsequent chapter on the Changes in the Membrana Tympani in various Affections of the Ear.

The spot at which perforation will finally occur may sometimes be accurately predicted. A small yellowish vesicle is seen to project into the meatus, and in the course of a few hours or a few days bursts and discharges its contents. In other cases there is no such distinct spot: the pus collected in the tympanic cavity bursts through the membrane, already softened by the inflammation, and is poured out into the meatus. Under such circumstances the opening is large and irregular in shape. In most cases, however, the opening is small; but those in which

xperienced. There is nothing characteristic
omena; they are also met with in catarrhal
hey are by no means constant in the purulent
plaint. They are due in part to increase of
to hyperæmia of the labyrinth and serou
character is apt to become modified during
disease. The noises in the ears are various
ing," "singing," "hissing," "throbbing,"
which the hearing is impaired varies co
ference can always be detected, and befo
place it is often very marked; but owin
other symptoms, it may not be fully r
is generally proportionate to the am
swelling of the mucous membrane, th
the condition of the sensorium. It i
the labyrinth be seriously involved.
conduction is preserved; in the ea
foration has occurred it is often incre
however, in scarlatinous, diphtherit
conduction is often considerably im

In children all the symptoms
type; but in adults they are m
minent. In these latter there
sorium; but a high temperat
sensation of fulness in the h
On the other hand, in cases
neither pain nor any parti
system; the process goes on
in the meatus or discharge
first indication of mischief
ptoms of pyæmia sometim
suppurative inflammation
thrombosis as a prelimi
phlebitis, and is more fr
tive otitis than with th

The **Objective** Sym
condition of the memb
in the meatus and su
bourhood of the ear
mastoid cells are inv

disorde
de.
ns
ail
ame.
ase t
pos
the
oper
ear
rane is in
retention
of the in
ase as time
ative change
additional pe
ates that he h
e during the
tion, on the ot
nic membrane i
been caused by t
the membrane, t
detected until a
When formed
e difficult to reco
often obscured by
ed up by shreds
however, the escap
and a pulsating r
be made out. The P
y enlarged arteries
transmitted to the exud
fluid occupying
in the carotid
for the discov
filled with fl
employed. and

apt to become swollen and reddened. The cartilaginous portion of the meatus is similarly affected, while the lining of the osseous portion is still more decidedly inflamed.

The internal or mucous layer of the membrana tympani, being continuous with the lining membrane of the cavity, participates in the inflammation, and the process extends to the other layers. The membrane is at first reddened and swollen, and soon loses its lustre; as the hyperæmia increases, it becomes more convex externally, and yellowish-red or bluish-red in appearance. Owing to the redness and swelling of the deep portion of the meatus, the circumference of the membrane is not clearly defined. There is marked injection of the vessels near the handle of the malleus; and later on, this part of the bone is often hidden by the swollen membrane, while a yellowish point indicates the position of the short process. When the exudation is profuse, the position of the handle of the malleus is marked by a furrow, on each side of which the membrane bulges out towards the meatus. The posterior portion is especially prominent; the epidermis often becomes detached at various spots, and the whole surface of the membrane is sometimes dotted over with little points, which more or less clearly reflect the light from the mirror. Ecchymoses, and the formation of minute abscesses between the layers, are sometimes noticed. Perforation occurs from the bursting of one or more abscesses, or from extension of ulceration. The opening is usually in the lower half of the membrane; and in three-fourths of the cases, in the anterior inferior quadrant. Bezold asserts that perforation is most common in the posterior inferior quadrant. Illustrations of various forms of perforation will be found in a subsequent chapter on the Changes in the Membrana Tympani in various Affections of the Ear.

The spot at which perforation will finally occur may sometimes be accurately predicted. A small yellowish vesicle is seen to project into the meatus, and in the course of a few hours or a few days bursts and discharges its contents. In other cases there is no such distinct spot: the pus collected in the tympanic cavity bursts through the membrane, already softened by the inflammation, and is poured out into the meatus. Under such circumstances the opening is large and irregular in shape. In most cases, however, the opening is small; but those in which the condition is associated with severe constitutional disorders, and especially with scarlet fever, are exceptions to this rule. It is generally large in tuberculous cases, and in those in which a spot previously atrophied gives vent to the discharge.

The Progress of the Case is somewhat less rapid than usual, and perforation is delayed, when the exudation occupies a nipple-shaped prominence in the posterior half of the membrane, and when the swelling forms in Shrapnell's membrane or close to the superior osseous margin. A crateriform opening in the posterior portion may indicate inflammation of the mastoid cells, the result of extension from the tympanum. In such cases the opening is usually very small, and the processes in the middle ear are apt to be very obstinate. When Shrapnell's membrane is involved, the secretion escapes with difficulty, and its retention may be accompanied by caries of the upper wall and of the incus and malleus. The loss of substance tends to increase as time goes on, and is liable to be associated with destructive changes in the ossicles, the formation of adhesions, and additional perforations in the tympanic membrane. Bezold states that he has never seen perforation of Shrapnell's membrane during the course of *acute* suppuration. In chronic suppuration, on the other hand, an opening in this portion of the tympanic membrane is decidedly frequent. When the perforation has been caused by the bursting of an abscess between the layers of the membrane, the opening is generally small, and cannot be detected until air has been forced through the Eustachian tube. When formed under other circumstances, the opening may be difficult to recognise during the first few days; its margin is often obscured by the swollen membrane, and it may be covered up by shreds of detached epithelium. Sooner or later, however, the escape of purulent matter becomes distinctly visible, and a pulsating movement with a reflection of light can often be made out. The pulsation occurs in the minute but abnormally enlarged arteries of the swollen mucous membrane, and is transmitted to the exudation contained in the tympanic cavity, and to the fluid occupying the perforation. It is possible that the pulsations in the carotid artery may likewise be transmitted to the fluid.

Other means may be adopted for the discovery of a perforation. Thus, if the meatus be filled with fluid, bubbles will appear when the air-douche is employed, and a powder blown into the meatus will be expelled by the same means. Another plan consists in the employment of the manometer, coupled with the air-douche, as a means of diagnosis.

As results of the escape of the exudation, the hyperæmia and swelling of the membrane gradually subside, and after the discharge has been wiped away with cotton-wool, the perforation appears as a dark opening, of variable size. In some cases the aperture becomes slightly enlarged during the next few days, but under ordinary circumstances the difference is never very great. On the other hand, the margin of the aperture often becomes swollen; growth takes place in the mucous membrane covering the inner surface, and sometimes to such an extent that the opening is occupied by a reddish mass resembling a large granulation. This appearance is often noticed in cases of prolonged suppuration, involving the accessory cavities of the middle ear. It is sometimes erroneously regarded as indicative of caries, and treated accordingly. The proliferation does not occur when grave constitutional disorder is associated with the middle-ear disease.

The Secretion which escapes from the meatus varies in character and quantity; it is at first sero-purulent, greyish-yellow in colour, and tinged with blood. After a few days it becomes more decidedly purulent. If the secretion contain much mucus, little yellowish masses, flakes, and threads will be found in the water after the syringe has been used. Pus, on the other hand, mingles more or less freely with the water. Blood is often mingled with the discharge in middle-ear suppuration occurring in cachectic subjects, and in cases due to injury. The escape of blood from the vessels is due, in some instances at least, to closure of the Eustachian tube. The resulting vacuum in the tympanum, or the approach thereto, produces hyperæmia and rupture of the vessels.

The changes discoverable in the nose, pharynx, and Eustachian tube are the same as those which accompany catarrhal inflammation. Obliteration of the canal of the tube, due to swelling of the mucous membrane, is often found in cases of suppurative middle-ear inflammation, and the air-douche will then yield a negative result. In the absence of perforation, if the mucous membrane of the tympanum be much swollen, and the cavity be filled with tenacious secretion, the injection of air will cause little, if any sound, even when the tube is permeable.

Course and Results.—The first stage of the disease, comprising the interval between the outbreak of the symptoms and the perforation of the membrane, varies in length in different cases. In the absence of treatment (*i.e.*, paracentesis) an opening is usually formed in the course of four or five days. In some cases, however, the membrane gives way before twelve hours have elapsed; in others, the opening is delayed for two or three weeks. These differences are due to the variations in the intensity of the inflammation, and in the kinds of bacteria that may be present, and likewise to the resistance which the membrane offers to the pressure of the exuded fluid. Rupture is apt to be delayed, if, as often happens in the case of adults, the membrane be thickened by calcareous or other deposits. It must also be remembered that in children the normal membrane is thicker than in after-life. The occurrence of perforation is generally followed by relief of all the symptoms, the change in this respect being very marked in young subjects. The patient's aspect becomes more natural; the restlessness or apathy is no longer prominent, and the head can be moved without signs of pain. If the previous symptoms continue, with but slight abatement, after the perforation has taken place, there is reason to suspect that the osseous walls of the cavity have become implicated.

The second stage of the process, viz., the interval between the occurrence of perforation and the closure of the opening, also varies in length in different cases. Its principal characteristic is the discharge, which gradually ceases; while the subjective sensations become less and less troublesome, and the hearing-power is more or less improved. When the opening is very small and the general condition of the patient not unfavourable, closure may take place in the course of a few days. In most cases, however, cicatrisation is not completed until several weeks have elapsed, but the period depends chiefly upon the severity of the previous inflammation. The membrana tympani gradually resumes its normal appearance, and, in some instances, scarcely any trace remains of the opening. More commonly, however, the spot is marked by a cicatrix, or by opacity or calcareous deposit. Opaque patches are frequently visible in other portions of the membrane. Tinnitus is often the last symptom to disappear; it may continue to be troublesome for some months, and then pass off.

In a somewhat large proportion of cases, the local and general symptoms reappear to some extent a few days after perforation has occurred. The patient is feverish and complains of pain, noises in the head, and other unpleasant sensations. These symptoms are due to retention and accumulation of the secretion, as a result of the closure of the opening either by adhesion of its margins or by masses of inspissated material. Such relapses may also be due to the influence of different kinds of micro-organisms. All these symptoms usually pass away under proper treatment; their persistence, in spite of local measures, would be suggestive of cranial complications.

The course above described is witnessed in favourable cases; there are, unfortunately, many others in which the progress of middle-ear suppuration is of a very different character. Instances of this type are not infrequent in connection with pharyngeal diphtheria and the acute exanthemata. The process in the ear is exceedingly rapid and intense; in the course of a few days, the tissues of the middle ear are partially or totally destroyed, the ossicles are detached and come away, and the membrane perishes in the suppuration. Complete deafness, or serious impairment of hearing, is the necessary result; and a history of this kind is attached to many cases of deaf-mutism, the children having lost their hearing-power before they were able to speak. In adults also, severe suppuration of the tympanum, associated with marked cachexia, tuberculosis, scarlatina, or typhoid fever, often results in serious damage to the cavity and its contents, with grave impairment of hearing, or even complete deafness, as a permanent result. Complications of various kinds exercise a more or less decided influence upon the course of the disease. Extension of the inflammation to the mastoid cells, the development of granulations upon the membrane or walls of the tympanum, and chronic inflammation of the meatus, frequently retard the progress of the case.

The **Results** of acute suppuration of the middle ear vary considerably in different cases; they may be briefly summarised as follows:—

(1) The symptoms may subside after perforation; closure of the opening and restoration of function being completed within a few weeks, or perhaps several months.

(2) Impairment or total loss of hearing-power, the result of permanent lesions within the tympanum. The position of the ossicles with regard to each other and to the wall of the cavity is liable to many alterations; if the ligaments be destroyed, the bones are more freely movable. In other cases, abnormal adhesions take place, and these have an opposite effect. Increase of mobility is, however, more common; the bones, no longer held together by the ligaments, become dislocated, and this change is especially liable to occur after extensive destruction of the membrane. One or more of the bones may be completely separated from the remainder, and escape with the discharge. This, however, is a rare accident, when compared with the frequency of middle-ear suppuration. In other cases, the ossicles become carious or necrotic. The articulation between the incus and stapes is most often affected by destruction of the ligaments. Purulent exudation in the labyrinth may be associated with these lesions of the membrane and ossicles.

(3) Mastoid periostitis, or inflammation of the mastoid cells, terminating either in recovery or in abscess with discharge externally; caries or necrosis of the mastoid process.

(4) Purulent inflammation in the Eustachian tube, and pharyngeal abscesses as a result.

(5) Subsidence of the acute symptoms after perforation and the continuance of the discharge for an indefinite period, the condition being that of chronic suppurative inflammation of the middle ear, which will form the subject of the next chapter. The disease frequently takes this course in tuberculous cases, and when it occurs in connection with scarlatina.

(6) The disease occasionally proves fatal, by causing one or other of the following conditions: meningitis, thrombosis of the sigmoid sinus, pyæmia, opening of the carotid artery as a result of caries of the wall of the canal. A fatal result is less common than in chronic suppuration of the middle ear.

Diagnosis.—In the early stages of the disease, the symptoms resemble those of acute catarrhal inflammation; but they are usually more severe. The nature of the case becomes evident when the membrane bulges out into the meatus, and yellowish pus can be seen through it, or when a pustule occupies the most prominent part of the swelling. It must be remembered that portions of the inner wall of the tympanum can sometimes be seen through the membrane, and care must be taken not to mistake these for collections of pus. Behind and a little above the lower extremity of the handle of the malleus, a slightly yellowish spot is sometimes visible; this is due to the yellow rays reflected from the promontory.

After perforation, the diagnosis is made (1) by ocular inspection and by observing the peculiarities of the secretion which escapes; (2) by injecting air into the tympanum and listening to the sound produced in the opening; (3) by condensing or exhausting the air in the external meatus. In examining the ear in order to detect a perforation, it is sometimes necessary to inject air, either by Valsalva's or Politzer's method, or through a catheter, in order to separate the margins of the aperture and to force out plugs of pus and débris. Syringing may also be employed for cleansing the meatus. Inflation of the middle ear, with auscultation, will confirm or establish the diagnosis. If the perforation be small, a whistling or hissing sound is heard as the air passes through it. Politzer's method is likely to be more efficacious than Valsalva's, as the air passes with greater force. When a perforation exists and air is condensed in the external meatus, as by the use of Siegle's pneumatic speculum, the air passes along the Eustachian tube into the throat, and the sound can be heard by means of a tube introduced into the nares. On the other hand, when the air in the meatus is exhausted by means of a Siegle's speculum, the fluid contents of the tympanum are drawn through the perforation, and may be seen flowing into the meatus.

Prognosis.—The complaint is not specially dangerous to life in persons otherwise healthy, and provided that suitable treatment be adopted from the commencement and throughout the progress of the disease. The most important favourable symptoms are: early occurrence of perforation and escape of secretion; rapid subsidence of fever and subjective sensations, and absence of complications. Evidences of tuberculosis, syphilis, or of general malnutrition are to be regarded as unfavourable. When the middle-ear affection is associated with scarlatina or diphtheria, the case is likely to be very serious, and the restoration of the affected parts to a normal condition is highly improbable. Other symptoms of an unfavourable character are: intensity and duration of the pain; signs of cranial mischief; frequent recurrence of rigors and fever; evidences of mastoid inflammation and detachment of the ossicles. It seldom happens that *acute* middle-ear suppuration leads immediately to a fatal result. Such an ending is generally due to caries or necrosis and their consequences, and the patients are usually the subjects of some constitutional disorder, the presence of which materially affects the prognosis.

Gruber has pointed out that the age of the patient has to be taken into account, and for the following reasons: In very young children, the lateral sinus is separated from the mastoid cells by a wall of osseous tissue, which is relatively thicker than in adults. In old age these cells are often obliterated, and hence the danger of extension of morbid processes from the ear to the cranial contents is less at the two extremes of life than during the intervening period. Both in young and in aged subjects the tendency of any extension of the mischief in middle-ear suppuration is rather towards the surface than in the opposite direction.

The hearing-power may be permanently more or less impaired, and on this subject a very guarded prognosis is always necessary. In many cases complete restoration ensues, but such a result cannot be definitely promised. Unfavourable symptoms in this respect are: persistent and profuse discharge, especially if hæmorrhagic in character; persistent subjective auditory sensations; considerable and rapid destruction of the membrana tympani; detachment of one or more ossicles; signs of mastoid inflammation and loss of bone-conduction. If improvement of the hearing-power take place simultaneously with the subsidence of the inflammation, a favourable result may confidently be expected; but in the absence of any such change the prognosis must be very guarded.

Treatment.—In the early stages the measures required are the same as those recommended for acute catarrhal inflammation. The patient must be kept at rest and on low diet; stimulants of all kinds should be avoided, and if the bowels are confined, suitable purgatives should be administered.

Except in debilitated subjects leeches should be applied in front of and behind the ear, and internal to the lobule, with the object of lessening the pain and hyperæmia; and this treatment, if followed by relief, may be repeated several times. In the case of an adult, six or eight leeches may be applied. If a leech-glass is not at hand, a small test-tube answers the purpose very well. The part to which a leech is to be put should be washed with warm water, and if the leech will not bite, a drop of milk may be placed on it; or, as a last resource, the part may be pricked with a needle, and a drop of blood smeared over it. The application of cold, by means of ice-bags, is sometimes recommended; but the effects are for the most part unsatisfactory. On the other hand, relief is generally obtained from moist and hot applications, such as a hot sponge or compress. These, however, should not be continued for more than two or three days; by hastening the destructive process, they are liable to act prejudicially upon the deeper parts of the ear. A little warm water poured into the ear from time to time will serve to relieve the pain; it should be allowed to remain for a few minutes and then removed. A few drops of tincture, or, what is better, the liquid extract of opium, may be added to the water. Ten to fifteen drops of a 10—20 per cent. solution of hydrochlorate of cocaine, previously warmed (see page 154), may be used for the same purpose. Atropine sometimes acts satisfactorily in these cases; but its use requires great care. Three or four minims of the Liquor Atropinæ Sulphat. are instilled into the meatus every three or four hours, and allowed to remain for about ten minutes. If there be decided tenderness over the mastoid process, a blister or mustard plaster should be applied. With the object of reducing the severity of the complaint in the early stages, tampons charged with a 20 per cent. solution of glycerine of carbolic acid may be introduced into the meatus. When fever is a marked symptom, antipyretics are likely to prove useful; acetanilide (antifebrin), in doses of three or four grains or more every four hours, and antipyrin in doses of ten grains or more at an hour's interval, are good remedies of this class.

Paracentesis.—When there are positive signs of purulent formation within the tympanum—that is, when the membrane bulges out into the meatus, and the swelling is greenish or yellowish in colour, and there is severe pain and high fever—paracentesis is strongly indicated. An incision into the membrane not only provides a suitable outlet for the escape of the pus, but reduces the hyperæmia of the tympanic vessels, relieves the tension and pain, and lessens the duration and risk of extension of the morbid process. Prompt mitigation of the pain is the almost

rigors and fever; evidences of masto
ment of the ossicles. It seldom ha
suppuration leads immediately to a
is generally due to caries or necros.
the patients are usually the sub
disorder, the presence of which

Gruber has pointed out that
be taken into account, and for
young children, the lateral sin
cells by a wall of osseous tiss
in adults. In old age the
hence the danger of extension
to the cranial contents is le
during the intervening pe
subjects the tendency of any
ear suppuration is rather to
direction.

The hearing-power may
and on this subject a very
In many cases complete
cannot be definitely pr
respect are: persistent
rhagic in character:
considerable and rapid
detachment of one or
tion and loss of bone—
power take place
inflammation, a fav
but in the absence
very guarded.

Treatment.—In
same as those re
The patient must
of all kinds sho
suitable purgati

Except in
front of and be
object of lesse
if followed
of an adul

n should not be
k of damage to
es more serious.
e pus has been
sfactory than when
sly. As a general
r half of the mem-
collection gravitates
er, the yellowness be
wing that the pus is
re, the incision should
a preliminary step, it is
to it a one per thousand
This may be allowed to
removed, the meatus being
n-wool. To produce local
ution of cocaine may be
eration of paracentesis has
51). When practised for the
ation of the tympanum, the
be made sufficiently large—
hat the exudation may free
ecessary if the pus be thick an
ten swollen and infiltrated.
ss through a considerable amo
ached.

es those mentioned above
. Thus, in the absence of
membrane, if the pain be very
an exploratory incision will
be borne in mind that the
d and indurated in conseque
der such circumstances a purul
middle ear without causing any
meatus.
ich usually causes but little hæm
more or less freely; if it
the meatus should be filled seve
Politzer recommends the insti
solution of pilocarpine, for th
per cent. solution

of making the secretion more fluid. If pain continue after paracentesis, or after spontaneous perforation, the anodynes cocaine and atropine (as described in a former paragraph) or warm liquid extract of opium should be dropped into the ear.

When an opening has been made, whether by puncture or by spontaneous rupture, the meatus should be thoroughly cleansed several times daily with pure warm water, or a warm solution of boric acid ; the frequency with which the injections are used must be regulated by the amount of secretion. If the latter be very abundant, the meatus should be washed out every two hours. After the injections, the canal should be carefully cleansed and dried, and a plug of cotton-wool introduced.

The injection, however, of warm water into the meatus will not remove all secretion from the middle ear; other means must be adopted for this purpose, and the best plan is to inject air through the Eustachian tube by Politzer's method. There are, however, certain drawbacks connected with the employment of the air-douche. In the first place, micro-organisms are likely to be conveyed to the tympanum from the nose and naso-pharynx. This risk can, at least to some extent, be averted by a preliminary disinfection of these cavities. Rohrer recommends peroxide of hydrogen as a suitable disinfectant, to be followed by insufflations of iodoform, iodol, or aristol. There is another danger, viz., that of forcing particles of secretion into the mastoid antrum or into the pouches of the tympanic cavity, which were previously free from disease. When the tympanum is filled with tenacious secretion, even a strong current of air may only break up the mass, without forcing it through the opening in the membrane. The case is of course different when the secretion is altogether fluid in character. If the pouches of the tympanum be already filled with secretion, a current of air, passing upwards from the Eustachian tube, cannot clear these spaces, but the secretion is likely to be driven into the mastoid cells, and to aggravate the condition of those cavities.

These drawbacks are, however, more than counter-balanced by the results often produced by the employment of Politzer's method. If there be considerable obstruction in the tube, the catheter may be employed for the injection of air. When the exudation is very abundant and tenacious, the injected air may fail to propel it through the perforation. Under such circumstances it is best to wash out the tympanum with a warm solution of common salt (¾ per cent.) previously sterilised and injected through the catheter. This solution generally diminishes the tenacity of the exudation, which is forced into the meatus, provided that the aperture in the membrane be sufficiently large. In the event of failure, the catheter should be laid aside for a few days, during which the meatus is to be frequently cleansed by the use of the syringe, as already described.

For the majority of comparatively mild cases, the injection of air into the middle ear is all that is necessary; in a few days the discharge ceases, and the aperture gradually closes. As a general rule, however, local remedies are required to check secretion and to restore the parts to a normal condition. The best remedy for this purpose is boric acid, reduced to a very fine powder. Before using it, the meatus should be washed out with warm water and carefully dried with absorbent wool. A small quantity of the powder is then blown into the meatus by means of an insufflator, and a plug of cotton-wool is introduced. This treatment is to be repeated several times daily, until no discharge appears on the cotton-wool which has remained in the meatus for twenty-four hours. Politzer recommends that, if no decided lessening of the secretion is observed within a few days, a little plug of iodoform or some cotton-wool dusted over with the same drug, should be passed down the meatus and kept in contact with the membrane, and that after this plan has been adopted for a short time, the boric acid should be again applied.

As the continuance of the discharge is frequently due to retention of pus in the tympanum, in preference to changing the application of boric acid for that of another drug, the author's usual practice is to have the meatus syringed out, and then a Politzer's inflation is given to force the discharge out of the tympanum. The syringing and Politzer's inflation should then be repeated alternately until the water which comes away is free from pus or mucus. In such a case it is better to syringe the meatus with a warm solution of biniodide or perchloride of mercury (1 in 1,000—1 in 2,000) or of carbolic acid (1 in 40—1 in 80) instead of with water or a solution of boric acid. When this treatment is adopted several times daily for a few days, the discharge usually diminishes greatly or entirely ceases. The inflation is contra-indicated if it produce pain.

If this treatment fail to check the discharge, astringent remedies should be tried; of these, sulphate of zinc and acetate of lead are the most useful. The instillation of dilute Liquor Plumbi Subacetat. (♏i.—ij. to ♏x. warmed distilled water) may be used thrice daily for a few days, and afterwards less frequently, and should be allowed to remain in the meatus for about ten minutes. It causes less irritation than other astringents, and often checks suppuration within a few days. After removal of the fluid, the meatus is carefully dried with absorbent wool. The sulphate of zinc is used in the form of a watery solution (2—5 grains to the ounce); twenty drops, warmed, are poured into the ear and allowed to remain for ten or fifteen minutes. The instillation is made once or twice daily, and continued for five or six days. A solution of acetate of lead, of the same strength, may be used in a similar manner. In some cases the addition of tincture or liquid extract of opium to the above-mentioned solutions, in the proportion of two drachms to each ounce, proves beneficial. As a general rule, astringents are not advisable so long as the patient complains of pain in the ear.

The treatment of cases in which spontaneous perforation has taken place is to be conducted in much the same manner as that already described. It is important that the exudation should freely escape, for if it be pent up within the cavity, complications are likely to occur. Extension of the process to the mastoid cells is by no means infrequent. Retention of secretion may be due either to smallness of the aperture or to its position in the upper part of the membrane. In the former case, the aperture should be enlarged with the paracentesis knife; and in the latter, a second opening should be made in the lower part of the membrane if there is evidence that the retained secretion is keeping up the inflammation or causing its extension, otherwise time should be allowed for the symptoms to disappear in their ordinary course. The alternate syringing and injection of air, as just described, is often sufficient to keep the tympanum clear, although the perforation is in the upper part of the membrane. Implication of the mastoid cells is marked by local pain, tenderness, redness, and swelling. To relieve these symptoms leeches should be applied behind the ear, and followed by an ice-bag or cold compresses. When the redness and swelling have subsided, liniment or equal parts of liniment and tincture of iodine painted over the process will help to promote resolution. If no benefit be obtained from these measures, or from the injection of warm water through the catheter, and if the mastoid region remain swollen and painful, it should be opened up. The treatment of inflammation of the mastoid process will be fully described in subsequent pages.

When the opening resulting from spontaneous perforation is sufficiently large and favourably situated for the escape of discharge, the treatment depends upon the nature of the secretion. If the latter be thin and serous, and escape freely, all that is necessary is to keep the meatus clean by syringing and careful drying, and to apply boric acid by insufflation. If the secretion be purulent and offensive, the air-douche or the use of the catheter daily, and antiseptic fluids for syringing into the meatus, will constitute the best treatment. It may be necessary to enlarge the opening in the membrane, or to make a second. Excoriations or ulcers in the meatus generally heal as the character of the secretion becomes improved; the application of white precipitate ointment (1 : 20) will prove efficacious. Granulations sometimes form on the margin of a perforation; but they usually subside as the secretion diminishes. If they prove troublesome, they should be lightly touched with the point of a fine probe coated with nitrate of silver or with a solution of chromic acid, ten grains to the ounce.

After the opening in the membrane has closed, an interval of three or four weeks should be allowed to elapse; the air-douche may then again be used with advantage, provided that the membrane is no longer swollen, especially in the neighbourhood of the short process. The air should be injected twice a week for four or five weeks, very slight force being used at first. The ear must be protected as far as possible from injurious influences; a plug of cotton-wool or gauze should be worn for several weeks, and all probable causes of a relapse should be scrupulously avoided.

The symptoms and treatment of mastoid complications supervening in acute middle-ear suppuration will be fully described in a subsequent chapter.

CHAPTER XXVIII.

CHRONIC SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR.

Statistics showing Frequency of the Complaint—Morbid Appearances in the Tympanic Cavity and Membrane—Caries of the Ossicles—Suppuration in the Upper Tympanic Spaces—The Eustachian Tube—Causes—Influence of Age, Sex, etc.—Subjective Symptoms—Impairment of Hearing, Tinnitus, Giddiness—Pain as a Symptom—Evidences of Nervous Disorders—Objective Symptoms—Discharges from the Ear—Micro-Organisms—Condition of the Membrana Tympani—Perforations, their Size, Form, etc.—Condition of Tympanum—Portions and Structures Visible through a Perforation—Perforation of Shrapnell's Membrane—Suppurative Processes in the Attic—Course and Results of Chronic Middle-Ear Suppuration—Diagnosis of Perforations—Prognosis—Treatment—Various Methods of Cleansing the Middle Ear—The Syringe, Inflation, Enlargement of the Opening—Aspiration, Condensation of Air, Dry Cleansing—Use of Antiseptics—Boric and Carbolic Acids, etc.—Caustics, Nitrate of Silver—Astringents—Gelatin Bougies—Constitutional Remedies—Methods of Improving the Hearing-Power.

THIS complaint is accompanied by a discharge from the meatus, and hence it is often described as "Otorrhœa." It is the most frequent as well as the most important disease to which the aural structures are liable. The statistics of 48,780 cases of ear-disease show that the middle ear was affected in 66·9 per cent.; the external ear in 25·5; while 7·6 represented the percentage of affections of the internal ear.* Of all middle-ear affections, 29 per cent. belong to the suppurative class. The Registrar-General's reports show that 300—400 deaths occur annually from what is vaguely termed "otitis." The mortality, however, is far greater than would appear from these figures. Not a few fatal cases of suppurative ear-disease are probably returned under the headings "Meningitis," and "Unclassified Brain-diseases." With respect to "Otitis," it may be regarded as certain that chronic middle-ear disease is implied by this term when used in the reports. Suppuration of the external ear very rarely causes a fatal issue, while the internal ear is seldom, if ever, the seat of inflammation leading to suppuration. Acute inflammation even of the middle ear is comparatively seldom followed by cranial complications; the lymphatics are intact, and any septic matters which may find their way into the cavity are probably destroyed.

---

* As cited in a lecture delivered at the Royal College of Surgeons, June 3, 1889, by Prof. A. E. J. Barker.

Morbid Appearances.—In chronic middle-ear suppuration, the continuance of the process is due to various causes, the most important of which are (1) the development of granulations on the mucous membrane of the tympanic cavity; (2) smallness of the perforation, and its unfavourable position, whereby escape of secretion is checked; (3) retention of masses of exudation and development of cholesteatoma; (4) formation of adhesions closing up portions of the cavity; (5) lesions of the osseous walls, and (6) ill-health, due to constitutional disorders. One or more of these conditions may be present in any given case. The mucous membrane undergoes many changes, varying with the stage of the disease. It is generally thickened as a result of excessive infiltration with round cells, and of vascular dilatation with formation of new vessels. The surface is often dotted over with papillary excrescences or nodules, which amount to granulations, and are frequently polypoid in character. The epithelial cells lose their cilia, and either become indurated or undergo fatty degeneration. Atrophy of the lining membrane is another result of purulent inflammation, and may be regarded as due to a more severe type of the disease. In this form there is no increase of tissue; on the other hand, the normal elements disappear and are not replaced; the newly-formed cells do not become organised, but are rapidly detached and discharged with the pus. Thus it is, that when examining the tympanum from the external meatus, through a perforation, in some cases a thick layer of connective tissue is seen to cover the inner wall; in others, the osseous surface is visible through a very thin layer of membrane.

Ulceration results from the replacement of the sub-epithelial layer by a mass of round cells, which form a granulating surface, traversed by dilated vessels. The lining membrane is of a deep-red or yellowish-red colour; the general thickening and the papillary excrescences considerably reduce the size of the tympanic cavity, a large portion of which may be filled up by the hypertrophied mucous membrane. Important changes take place in the lymphatic vessels situated in the deeper layers; their trunks form an anastomosing network, and the radicles become varicose and constricted at intervals, and present many knob-like dilatations. Politzer also describes the formation of cyst-like cavities in the proliferated mucous membrane: those in the deeper layers are to be regarded as isolated lymph-spaces; while the minute sacs in the superficial granulation-layers are probably due to the cohesion of papillary excrescences, which thus shut off the little depressions contained between them. These cyst-like cavities are well adapted for the retention of infective matters, septic bacteria, etc. The part played by micro-organisms in the production of complications would seem to be of a very important character; it will be discussed at some length in subsequent paragraphs.

The changes, as above described, are not uniformly distributed over the mucous membrane of the middle ear; but different parts are often affected in different ways. Thus the formation of granulations in one part may be associated with the development of connective tissue, or with atrophy and loss of substance, in other portions of the membrane.

The **Membrana Tympani** is almost always perforated, and sometimes in two or more places; the size and shape of the openings vary considerably. In exceptional cases, the secretion escapes through fistulous channels in the bones, and the membrane may then be found intact. Such openings are usually found in the posterior and posterior superior walls of the meatus, and communicate with the mastoid cells or antrum. A perforation may at the same time exist in the tympanic membrane. With regard to the size of the perforation, it is sometimes very small, although it has existed for years. In cases in which the aural disease was associated with scarlatina or diphtheria, the opening is usually large; the destruction may indeed have involved the whole of the membrane, with the exception of a very narrow border next to the tendinous ring. Considerable alterations are often manifest in the remains of the membrane; thickening, opacities, and calcareous deposits are the most common changes. In most cases, the membrane is drawn decidedly inwards; and when the perforation is central, its margin is often closely applied to the wall of the labyrinth. If the perforation has closed, its cicatrix is often adherent to the same part. After a large perforation has remained open for a long time, the lining of the cavity sometimes becomes dermoid in character, owing to proliferation of epidermis from the external meatus.

The **structures contained** in the tympanic cavity are often bound together by layers and fibrils of connective tissue, extending in various directions; and sometimes these bands and portions of the lining membrane become indurated, calcified, or even osseous in texture. The malleus may be found adhering to the promontory; or a cicatrix in the membrane may be connected with the long process of the incus, or with the stapes, when the incus has disappeared. In another class of cases, destruction of tissue is the prevailing feature. The mucous membrane is ulcerated, and in some places the bone is either exposed or partially hidden by granulations. The roof and inner wall of the tympanic cavity are the parts most often affected. Caries is another result, evidences of which are frequently seen in the ossicles as well as in the bony walls. This process, which may be confined to the incus or to the malleus, renders the suppuration obstinate. The discharge, loaded with micro-organisms, trickles down to the floor of the cavity, the tissues of which are constantly exposed to reinfection. The attic of the tympanum, Prussak's space (see page 46) and the anterior and posterior tympanic pouches, are sometimes filled with purulent matter, the presence of which leads to destructive changes, especially to perforation of Shrapnell's membrane, and to caries or necrosis of the malleus and incus. Purulent processes in this system of cavities (with perforation of Shrapnell's membrane) may either localise themselves and not spread, or may involve the entire cavity. Even in the latter case, the suppuration in the middle ear may come to an end, while it continues almost indefinitely in the system of cavities between the body of the malleus, incus, and Shrapnell's membrane. Purulent processes may be very obstinate in a space occupied by a meshwork, from which stagnating secretion cannot be thoroughly removed, and the hidden crevices of which are with difficulty accessible. In these cases, if the original perforation should heal, another opening is likely to form in Shrapnell's membrane. Chronic suppuration in the mastoid antrum is prone to occur simultaneously with purulent processes in the upper tympanic spaces.

The **Eustachian Tube** is always more or less affected in cases of middle-ear suppuration. The mucous membrane is swollen and covered with secretion; the glands are enlarged and their excretory ducts dilated; the epithelium may be either thickened or detached. In some cases, the process is catarrhal in type; in others, decidedly purulent. Some amount of constriction often remains in the tube.

Causes.—Chronic suppurative inflammation of the middle ear is generally the result of an acute attack; in some cases, however, and notably in those due to tuberculosis, the disease is chronic in type from the commencement. The acute symptoms are apt to pass into a chronic stage in cases of scarlatina, smallpox, and measles ; and in tuberculous and syphilitic patients. A similar result may be caused by improper treatment, and is very liable to occur when the upper tympanic spaces are the seat of disease. The connection between scarlatina and diphtheria and affections of the middle ear is now thoroughly recognised; in both these diseases, the throat is often implicated, and the process extends through the Eustachian tube to the aural structures. As a general rule, it may be stated that from five to six per cent. of all diseases of the ears are due to scarlatina, the frequency with which the complication occurs being in proportion to that of the throat-affections and their severity. Diphtheria in children is liable to be followed by a very severe form of chronic purulent inflammation of the middle ear. There may be little or no pain, or any acute symptoms, but in a few days a discharge appears in the meatus, abscesses form around the ear, and portions of the bone soon become necrotic. A separate chapter will be devoted to the consideration of those forms of otorrhœa which originate in diphtheria, scarlatina, tuberculosis, syphilis, and other constitutional disorders.

According to v. Tröltsch and other German writers, purulent collections are often found in the tympana of new-born children. This appearance is due to abnormal metamorphosis of the embryonic connective tissue; to the passage of liquor amnii into the tympanum during futile attempts by the fœtus at respiration; and possibly to the entrance of matters from the stomach during the act of vomiting. It must also be noticed that the vascular supply is more copious in the fœtus than in the adult. In forty-seven temporal bones taken from new-born children, v. Tröltsch found that the aural structures were normal only in eighteen preparations; in twenty-six there were indications of purulent processes in the middle ear.

The complaint is most common in children; and both sexes are equally liable to suffer from it: in a majority of cases (58 per cent.) only one ear is affected. Many of the sufferers belong to the poorer classes, who are more exposed to cold and damp, and to other injurious influences. Dr. Burnett points out that among the well-to-do classes, girls form the majority of young patients. They are more closely observed than boys, and therefore are more often placed under treatment. Boys are more liable to be neglected until impairment of hearing causes them to lag behind their schoolfellows.

Subjective Symptoms.—These vary in different cases; many patients appear to be almost free from them, and complain only of the discharge. There is usually more or less deafness; but it is sometimes so slight as to pass unnoticed, and especially if only one ear be affected. In some cases, however, the hearing is decidedly impaired; and this symptom may be due either to obstacles to conduction or to changes in the labyrinth. The former is the more common cause; the comparative infrequency of labyrinthine complications is a distinguishing mark between chronic middle-ear suppuration and the adhesive processes. Bone-conduction is maintained; in cases of unilateral disease, the tuning-fork applied to the vertex is best heard on the affected side. Rinne's test gives negative results. The degree in which the hearing is impaired depends in some measure upon the position of the opening in the membrane. Perforations in the anterior portion are more likely to impair the function than similar openings in the posterior part. Comparatively slight alterations may be noticed even with large perforations involving the posterior superior segment, and exposing the articulation between the incus and stapes. When the cone of light is destroyed, the hearing-power is apt to be decidedly lessened. Most patients are conscious, from time to time, of considerable variations, which depend upon the state of the weather, the condition of the tympanum and Eustachian tube, and particularly upon the nature and quantity of the secretion. Warm and dry weather tends to improve the hearing. A thick tenacious secretion has a contrary effect, inasmuch as it impedes the movements of the ossicles. Sometimes the exudation is so scanty that otorrhœa cannot be said to exist; in these cases crusts often form and emit a very disagreeable odour. The hearing-power is not uniformly affected by the cessation of suppuration; in many cases the deafness increases with the subsidence of the process, and is lessened when the discharge again becomes free. The change for the better is probably due to the relaxation of the connective tissue, and to the increased mobility of the ossicles under the influence of the liquid secretion. If the fenestræ are blocked up by the hypertrophied mucous membrane, and the base of the stapes is fixed, cessation of the discharge is not likely to be followed by any improvement of function.

Subjective Sensations, noises of various kinds, are seldom very troublesome, and in many cases are altogether absent. Some patients are subject to occasional attacks, which depend upon the condition of the Eustachian tube and tympanic mucous membrane. Tinnitus is likely to be troublesome when the labyrinth is involved, and when there is ankylosis of the articulations between the ossicles. Giddiness is an occasional symptom; it may result from increased pressure in the labyrinth, or from extension of the hyperæmia of the tympanic vessels through the petro-squamous fissure to the meninges. Suppuration in the attic is especially liable to cause giddiness. An attack is sometimes produced by stooping, and by suddenly rising up from the recumbent position; syringing the ear with cold water, and with too great an amount of force, is likely to have a similar effect.

Pain is by no means a constant or prominent symptom in chronic middle-ear suppuration; usually patients complain only of uncomfortable sensations on the affected side of the head. The supervention of an acute attack will be accompanied by severe pain, which lasts until the parts have returned to their former condition. Occlusion of the perforation, preventing the escape of the discharge, is a common cause of the return of pain.

Carious processes in the walls of the cavity may give rise to severe boring pain, extending over the side and back of the head. The sudden occurrence of severe pain renders a careful examination very necessary; and persistent headache on the affected side may be indicative of intracranial complications.

Various Evidences of Nervous Disorder are occasionally witnessed. Sometimes taste is impaired or even lost on the affected side, and diminution of tactile sensation in the tongue has also been noticed. Facial paralysis is another symptom of this character, and is most often due to carious processes involving the aqueduct of Fallopius, though it may be caused by pressure of exudation in the canal. Urbantschitsch mentions impairment of vision and nystagmus as occasionally due to the condition of the tympanum. In one case, recorded by Schwabach,* pressure upon the wall of the tympanum caused nystagmus, with movements towards the affected side. Psychical disorders of various kinds and epileptiform convulsions are sometimes due to chronic middle-ear suppuration; and an obstinate cough and frequent paroxysms of sneezing have been observed to accompany a chronic discharge from the ear.

Objective Symptoms.—On examining the meatus, it is generally seen to contain inspissated or fluid pus, and the walls of the canal are swollen and inflamed. When the discharge is only slight, the secretion may be confined to the deep part of the meatus or to the tympanum. The quality, as well as the amount of the discharge, varies considerably in different cases and at different times in the same case. Sometimes the secretion is thick and scanty, and only a few drops are discharged in the course of twenty-four hours; or perhaps it becomes dry in the meatus and forms crusts. In other cases the discharge is watery and profuse, or even so abundant as to trickle almost continuously from the ear. In a case recorded by Itard, 200 grammes (about seven ounces) of fluid were discharged in seven days. Abundant secretion is the rule in cases associated with scarlatina and diphtheria, and when the tympanum is decidedly granular or the temporal bone has become carious with subsequent formation of abscesses. The discharge often contains crumb-like masses of inspissated pus and of epithelial cells. Variations in the quality of the secretion are very numerous; thus the discharge is sometimes purulent, sometimes muco-purulent or serous and tinged with blood. Less frequently it is viscid, resembling a solution of gum. Stiff, tenacious crusts are then apt to form and to irritate the walls of the canal. The colour likewise varies; it depends upon the relative proportions of pus, mucus, serum, blood, débris, and micro-organisms; it may be pure yellow, greenish-yellow, reddish, or brown; it is sometimes decidedly blackish. In rare cases, the discharge is blue or bluish-green in colour. Pus of this character is sometimes noticed covering granulating sores on various parts of the body. The colouring matter is contained in the serum and not in the albumen; it is due to micrococci, containing a blue material called "pyocyanin." These organisms (*M. pyocyaneus*) require for their development a temperature equal to that of the body and the presence of albumen; they are not found when the discharge is profuse. If a drop of this blue pus be placed in the meatus of a patient suffering from ordinary otorrhœa, the discharge, in a few days, will become similarly coloured. The organism is quite innocuous, and its presence does not interfere with the course of the healing process. Cholesteatoma will be subsequently described.

---

* *Deutsche Zeitung f. prakt. Heilk.*, 1878, 1.

A highly disagreeable odour is another common feature of the discharge in cases of chronic middle-ear suppuration. The odour varies in character; sometimes it is described as "faint" or "sickly," sometimes as pungent and resembling decaying cheese. Mention has been already made (see page 404) of the various kinds of micro-organisms found in the middle ear in cases of suppurative disease. In 100 patients suffering from this disorder, and examined by Dr. Rohrer,* the discharge was more or less fœtid in sixty-nine cases, and contained many forms of micro-organisms. In 317 examinations, micrococci were found in 130 and bacilli in 177 specimens. In sixty patients the symptoms were of a chronic character, and bacilli proved to be more common than micrococci in the discharge (154 : 121). In the nine acute fœtid cases, bacilli were found in still greater proportions (23 : 9); in the cases (31) with non-fœtid discharge, micrococci alone were discoverable. The investigations showed that the odour of the discharge in fœtid otorrhœa was due to forms of putrefactive bacilli. The absence of bacilli from the non-fœtid discharges is a point of considerable interest. It must be remembered that an offensive odour does not necessarily indicate caries of the osseous walls, as was formerly supposed. In some cases the discharge acts as an irritant to the meatus, and causes circumscribed or diffuse inflammation, or even leads to ulceration; the floor of the meatus is the part most liable to be thus affected. In long-standing cases, the canal may be considerably reduced in size, owing to the swelling of the soft parts, and to chronic periostitis. Eczema of the auricle is another somewhat frequent accompaniment of middle-ear suppuration. The eczematous secretion contains various forms of bacilli and micrococci.

---

* *Zur Morphologie der Bacterien des Ohres und des Nasen-Rachenraumes*, Zurich, 1889.

The **Condition of the Membrana Tympani** is the next subject for investigation. As a preliminary step it is often necessary to cleanse the meatus, either by means of the syringe or with cotton-wool. Dark crusts sometimes adhere to the tympanic membrane and adjacent parts of the canal, and are difficult to remove. When the discharge is scanty, little, if any, may escape into the meatus; it adheres to the edges of the perforation, and a small opening may be thus entirely occluded.

The appearances presented by the tympanic membrane exhibit great variations. In all but exceptional cases, an aperture exists in this structure, so that the meatus communicates with the middle ear. The opening may be situated in almost any portion of the membrane, but the anterior inferior quadrant is the most common site. Next to this comes the posterior inferior quadrant, and in many cases both these quadrants are involved. In 53 per cent. of all cases, the perforation is either confined to or involves the anterior inferior quadrant. When both sides are affected, the perforation is often found in the same part of each membrane, and its shape is often similar on each side. Perforation of Shrapnell's membrane takes place, according to Bezold,* in 1·2 per cent. of all cases. This author has paid especial attention to these perforations, and while noticing that they do not occur in the course of acute middle ear suppuration, he attributes them to co-existing or preceding affections of the Eustachian tubes. He thinks that rupture of Shrapnell's membrane occurs suddenly, as a result perhaps of sneezing, and that the margins soon become adherent to adjacent parts, thus constituting a permanent opening. Destruction of the ossicles and the formation of cholesteatoma are frequent results in such cases.

---

* *Uebersohau über den gegenwartigen Stand der Ohrenheilkunde*, 1895, S. 115.

The **Size of a Perforation** is also liable to great variations. In some cases, the aperture is no larger than a small pin-hole; in others, the gap involves almost the whole of the membrane, and any degree of size may exist between these extremes. As already stated, the greatest destruction results from scarlatina and diphtheria, and from the effects of tubercular ulceration of the lining membrane of the tympanum. A narrow border generally remains at the circumference, and a similar strip is usually connected with the handle of the malleus. In very severe cases, Shrapnell's membrane is also involved, and the upper border of the tympanic ring, with the adjacent portion of the osseous meatus, is the seat of caries. A small opening is sometimes noticed to increase in size during the continuance of inflammation; and variations in measurement, due to increase or diminution of swelling, are not infrequent. Illustrations of various forms of perforation will be found in the next chapter.

The **Form of a Perforation** is in most cases roundish—that is, comparatively circular, oval, or elliptical. When the opening is large and involves the lower half of the membrane, the projection of the handle of the malleus may give it a reniform shape. In large perforations, with almost total destruction of the membrane, only a wedge-like piece may remain over the same process of bone, causing the opening to appear somewhat V-shaped above. In rare instances, the opening is funnel-shaped, with the wider end directed towards the tympanum. Another form of opening is a canal running obliquely through the layers of the membrane; and sometimes the coats are unequally destroyed, so that for some distance round the opening the membrane has an uneven appearance. Angular and slit-like perforations are somewhat rare; but when the membrane is the seat of chalky deposits, a cleft is sometimes noticed at the margin of the calcified portion. Occasionally a minute orifice is found at the apex of a prominent part of the membrane, and when this peculiarity occurs, the suppurative process is apt to be of a very obstinate character.

In most cases, only one opening exists in the tympanic membrane; but there are sometimes two or even more, and when this is the case, the openings vary in size. Perforations sufficiently numerous to give the membrane a sieve-like appearance are sometimes found in cases of tuberculosis, scarlatina, diphtheria, and pyæmia.

The **Appearances presented by the remains** of the membrane vary considerably in different cases and in different stages of the same case. While the discharge continues, the membrane is more or less swollen and reddish, or decidedly greyish in tint, owing to accumulation of epithelium on its surface. After removal of these shreds, the appearance of the membrane may be either comparatively normal or changed in various ways, *e.g.*, opaque, yellowish-red or deep-red in colour. Calcareous deposits cause greyish or whitish spots, between which a reddish hue may predominate. The surface may be either smooth or uneven, and covered in places with granulations. These latter frequently encircle the perforation and occupy its margin; they are likewise apt to occur near the periphery of the membrane. The margin of the perforation varies in appearance, and is notably influenced by the condition of the discharge. It is often covered up by secretion, and appears as a red line when this is removed. It is sometimes free and sometimes in contact with the inner wall of the tympanum, being either closely adherent or connected by membranous bands. In later stages, the margin may be covered with calcareous deposit; the occurrence of granulations has been already referred to.

Some portion of the handle of the malleus is often connected with the remains of the membrane, and its position is considerably modified when the perforation is large. In such cases, the tensor tympani, no longer opposed by the tympanic membrane, draws inwards the remains of that structure, together with the handle of the malleus, which may indeed be placed above the upper portion of the periphery, so as not to be visible from the meatus. If, on the other hand, in a case of almost total destruction of the membrane, the handle of the malleus be in a comparatively normal position, there is either a pathological change in the tensor tympani or some abnormal obstacle to the action of the muscle. Obstacles of this character are caused by ankylosis or rigidity of the malleo-incudal articulation, by immobility of the remains of the membrane with calcification or hypertrophy of its tissue, and by tension of the anterior ligament of the malleus, which antagonises the tensor tympani muscle. Partial destruction of the handle of the malleus, extending up to the short process, is not uncommon, and sometimes the long process of the incus and its articulation with the stapes are exposed to view.

The **Mucous Membrane of the Tympanum,** as seen through a large opening, varies in appearance with the stage of the disease. At first it is red and swollen, and more or less covered with exudation. If the swelling be inconsiderable, various parts of the inner wall may be more or less clearly distinguished; under opposite conditions, all that can be seen is a reddish mass, either smooth or covered with granulations or polypoid growths. Such excrescences sometimes project through the opening in the membrane. After the inflammation has subsided, the lining of the tympanum becomes either yellowish-red or yellowish-white; it may undergo atrophy and resemble cicatricial tissue. Calcareous deposits are not uncommon appearances. Masses of inspissated secretion and detached epithelium often project below the upper border of a large perforation.

Various Portions of the Inner Wall of the tympanum and of the structures contained in the cavity can sometimes be distinguished through the opening in the membrane. In cases of large and central perforations, the promontory, with numerous vessels on its surface, the vertical limb of the incus and the depression of the fenestra rotunda, are more or less distinctly seen. When the opening involves the posterior superior quadrant, in addition to the limb of the incus, portions of the stapes, and sometimes the tendon of the stapedius muscle, may come into view. When the lower half of the membrane is absent, the cells in the floor of the tympanic cavity may become exposed, while anteriorly, the opening into the osseous portion of the Eustachian tube will appear as a dark depression.

Perforations of Shrapnell's Membrane have been already noticed (see page 432); some of their peculiarities require a more minute description. They are usually indicative of chronic suppuration, and are especially frequent when the attic of the tympanum is the seat of the morbid process. Even in cases in which a perforation is formed in the lower part of the membrane, the suppuration may exist, principally or exclusively, in the spaces near the roof of the cavity; the opening is caused by the secretions which pass downwards. These spaces may, however, be subsequently cut off from the rest of the tympanum by membranous adhesions, in which case a second perforation is likely to be formed in Shrapnell's membrane, while the lower opening becomes closed.

Perforations in Shrapnell's membrane may occur in the anterior, posterior, or central portion. When in front they are generally connected with disease of the naso-pharynx; those in the posterior part are usually associated with suppuration in the mastoid cells; while central perforations are most frequently due to affections of the external meatus (Burnett). These last are more amenable to treatment than the anterior and posterior perforations. The discharge is generally very slight, but is liable to increase in quantity when suppuration coexists in the mastoid process. Under other circumstances, the meatus may be almost free from secretion; perhaps a slight film covers the perforation, which is not distinctly visible till the part has been cleansed by the syringe or cotton-wool. If the opening be comparatively large, and not occluded by granulations, more or less of the malleus and of the body of the incus may be visible through it. As a general rule, in the absence of treatment, the process of destruction extends to the osseous boundary above, so as to expose more and more of the superior and posterior middle-ear spaces, while the malleus and incus and the upper part of the tympanic membrane likewise perish. In a subsequent stage, the lining of the spaces becomes to a greater or less extent epidermoid in character ; and the formation of layers may go on rapidly, so as to produce the condition known as cholesteatoma.

Suppurative Processes in the Attic are characterised by peculiar obstinacy, due, in great measure, to the anatomical conditions of the part (see page 31). The passage communicating with the tympanum is often very narrow, and the escape of secretion readily becomes impeded. The fluid portion may trickle downwards, but inspissated matters remain behind, and the morbid processes are thereby prolonged. Caries of the adjacent portions of the ossicles and bony wall is often superadded; granulations then form, and sometimes project through the perforation into the meatus. Disease of the bones and the development of granulations aggravate the suppurative processes; and if the roof of the tympanum be involved, intra-cranial complications are likely to ensue. The destruction is sometimes very considerable; the greater part of the malleus and incus disappears, a large gap is made in the bone above, and the process may likewise extend to the remainder of the membrane.

Masses of inspissated secretion and débris are apt to accumulate in these cases, and their volume is increased by detached epidermic cells. These latter are derived from the epidermis of the external meatus, which often prolongs itself, through a perforation, into the tympanum. It may, indeed, extend into the mastoid cells. These masses of epidermic cells are most abundant where the mucous membrane has been destroyed; they constitute the growths termed "cholesteatoma," a description of which will be found in a subsequent chapter. Their development in the attic and in the tympanum generally tends to fill up these spaces, and fresh inflammation may ensue as a result of the pressure. If purulent secretion take place, the epidermic masses may become softened and detached; but if they remain long in the cavities, their increasing size causes atrophy of any remnant of mucous membrane and of the osseous walls. When comparatively dry, these masses are found to consist of a thin shell of epidermis enveloping a nucleus of inspissated pus and débris. They can often be extracted from openings in the attic, and from fistulous channels in the mastoid process. They rapidly swell when placed in water.

The occurrence of suppuration in the attic, confined to the divisions situated close to the perforation in Shrapnell's membrane, has been explained in various ways. The view that the process is of primary origin is opposed by some on the ground that the action of micro-organisms passing through the Eustachian tube could scarcely be confined to these spaces, while the lower portion of the tympanum remained unaffected. Prof. Walb* thinks that there are two ways of accounting for suppuration in these spaces. In the first place, during middle-ear suppuration, when the Eustachian tube is closed and the tympanic membrane is drawn inwards, the exudation may force its way through Shrapnell's membrane. As already mentioned, Bezold thinks that occlusion of the tube and drawing-in of the tympanic membrane are sufficient *per se* to cause a rent in Shrapnell's membrane, and that through such an opening the epidermis of the external meatus may extend itself into the attic. This latter process, however, cannot take place until the epithelial covering of the space has been destroyed.

---

* Schwartze, *Handbuch der Ohrenheilkunde*, Bd. II. S. 268.

Suppuration confined to the attic may originate in another way, viz., by the passage of infective materials from suppurative processes in the external meatus through a minute opening in Shrapnell's membrane. Such openings are sometimes congenital; but they are by no means invariably present, and are not to be regarded as normal. Schwartze believes that middle-ear inflammation is sometimes due to the passage of water through such an opening during bathing. Mr. Field* is of opinion that a sharp attack of inflammation of the tympanic membrane and consequent perforation are sometimes due to sea-bathing; and further, that the micro-organisms contained in the water, often contaminated by sewage, are the excitants of the tympanic lesions. Be this as it may, there is no doubt that inflammatory processes in the external meatus may lead to partial destruction of Shrapnell's membrane. At the commencement, the disease in the attic may be confined to the immediate neighbourhood of the perforation; in another class of cases, the upper margin of the osseous boundary may be already carious, while the ossicles are still intact.

Chronic suppuration in the attic often runs its course in the absence of any disease in other portions of the tympanum. If the affected spaces are completely separated by adhesions, no perforation sound is heard when air is injected through the Eustachian tube, for the current will be prevented from reaching the opening in the membrane. If, however, the perforation be large and the lower part of the membrane be involved, the sound will be heard on injecting air.

Caries of the ossicles is a not infrequent complication of suppurative disease within the attic, and when this latter part is alone affected, the head of the malleus is most often involved. But when the perforation is larger and extends to the lower portion of the membrane, the continuance of suppuration is probably due to extension of the caries to the descending crus of the incus. With a still longer continuance of suppuration, the body of the incus is likely to become carious.

When a perforation exists in Shrapnell's membrane, the appearance of the lower portion is generally changed. It loses its polish and becomes dull and dry. This change is probably due to destruction of the vessels of the tympanic membrane, which in the normal state are found where the tissue of Shrapnell's membrane and of the osseous margin has been destroyed. The membrane is also generally much drawn in.

---

* *Diseases of the Ear*, Fifth Edition, p. 387.

Suppuration in the attic, with a perforation either above the short process or causing more extensive destruction, may in certain cases heal up and a cicatrix may form; but this result is very uncommon. The defect is usually permanent; more or less of the attic is exposed to view, no mucous lining is visible, its place being taken by a smooth, shining, pale-yellow membrane, almost dry and coated with epidermis. It very rarely happens that Shrapnell's membrane is entirely destroyed, but when such is the case, the neck and head of the malleus, the articulation with the incus, and a portion of the latter bone come into view. The roof of the tympanum, and posteriorly the beginning of the mastoid antrum are also visible.

The importance of chronic suppuration in the upper tympanic spaces is largely due to the dangers attendant upon the continuance of the process, which may extend not only to the mastoid cells but also to the membranes and brain. A very thin layer of bone separates these spaces from the latter structures, and cerebral abscess is a not infrequent complication of suppurative processes in the attic and Prussak's space, while the mastoid process may remain free.

The **Course and Results** of chronic middle-ear suppuration exhibit many and great varieties in different cases. Not infrequently the suppuration ceases, the appearances of inflammation pass away, and the perforation either remains open or is closed by a cicatrix. Such closure may take place soon after suppuration has ceased, or not until many months have elapsed. The hearing-power may be either completely restored, or remain impaired in various degrees. When the opening is persistent, exacerbations of the process in the tympanum are very prone to occur, as a result of exposure to cold, recurrent catarrh of the naso-pharynx, the passage of foreign matters and even of cold water through the perforation, etc.

The course of the complaint is influenced by the general condition of the patient, the existence of complications in the meatus, mastoid process, and osseous walls of the tympanum, and the state of the nose and naso-pharynx. The course is also decidedly affected by the nature of the constitutional disorders (*e.g.*, tuberculosis, scarlet fever, and diphtheria) with which middle-ear suppuration is often associated.

The course of the complaint is generally tedious when the tympanic cavity is occupied by granulations or polypoid growths, when the walls or ossicles are the seat of caries or necrosis, and when abscesses form in the neighbourhood of the ear. Purulent exudation may find its way through the petro-mastoid and squamo-mastoid sutures, and pass between the cartilaginous and osseous portions of the meatus and through the fissures of Santorini towards the parotid gland. Pharyngeal abscesses are rare complications; they result from suppuration in the Eustachian tube. The cartilaginous portion is loosened from its connection with the osseous part, and the pus either burrows between the structures at the back of the naso-pharynx, or passes into the tissues of the soft palate. In very severe cases, the two portions of the tube are completely separated, and the pus is infiltrated into the side of the neck as well as between the structures of the pharynx. In children, pus from the tympanum may find its way through the Glaserian fissure to the parotid gland and adjacent structures.

Another serious cause of complications, tending to lengthen the duration of the disease, consists in the formation of adhesions between the membrane and various structures of the tympanic cavity. The parts may be closely applied to each other, or may be connected by bands or fibrils of false membrane. More or less impairment of hearing is the necessary result, and the cavity is liable to be divided into separate spaces, difficult of access, and in which suppuration may be prolonged for indefinite periods.

Complications threatening the life of the patient may arise in the course of chronic middle-ear suppuration. They result either from extension of morbid processes to the contents of the cranium, or from the constitutional effects of the local disease. Extensive caries of the walls of the tympanum is by no means necessary for their development; they may rapidly supervene upon conditions regarded as comparatively mild and unimportant. They will be fully described in a subsequent chapter.

Diagnosis.—The existence of chronic suppurative inflammation of the tympanum can generally be ascertained without any difficulty. There is, in the first place, a chronic purulent discharge from the ear; and secondly, a perforation in the membrane. The discharge may, however, have ceased, in which case a perforation or a cicatrix may be the only sign of the previous condition.

The diagnosis of a perforation is effected (1) by direct inspection; (2) indirectly, by inflation of the middle ear; by injection of fluids through the Eustachian tube; by the passage of water into the naso-pharynx after injection into the meatus.

(1) The appearance of a perforation, as seen from the meatus, has been fully described (see page 432). If the membrane be drawn inwards and in contact with the wall of the tympanum, it may be necessary to force it outwards in order to detect the opening. To effect this purpose, air may be injected into the tympanum through the Eustachian catheter, or Siegle's speculum may be used to rarefy the air in the meatus. Inflation of the cavity serves also to distinguish cases of total destruction of the membrane from instances in which relaxation of its tissue allows it to be drawn inwards and closely applied to the inner wall, so that the mucous lining becomes clearly visible. Very small, slit-like perforations are apt to be overlooked on inspection; they will, however, be detected on inflating the tympanum. Inspection alone may also be insufficient to detect a perforation situated near the periphery, in the anterior and inferior portion, as there is often a bulging out of the external auditory canal in this position. It is just necessary to mention that minute deposits of blackish cerumen or of epithelial débris on the membrane, and dark atrophic spots and cicatrices, may present appearances somewhat like those of a perforation. A careful examination after syringing, and, if necessary, inflation of the middle ear, will determine the real nature of the case. Greater difficulty will arise when the field of view is occupied by an uneven granulating surface, which may belong either to the tympanum or to the membrane. One of the methods about to be described should then be practised.

(2) Inflation of the middle ear, either by the aid of the Eustachian catheter or by Politzer's method, causes a whistling

or hissing sound as the air passes through the perforation. The sound is most distinct when the opening is small, and may often be heard even without the use of the auscultation tube. It is much less distinct when the perforation is large and the air escapes freely. When the tympanic cavity contains fluid, bubbles will be formed by the injected air, and a corresponding sound will be audible; on inspection, the fluid mingled with air will be seen to come through the opening. If the fluid be removed, and inflation be again practised, the reappearance of secretion will indicate a perforation. Minute air-bubbles sometimes appear as dark globules in the deep part of the canal when the tympanum is inflated; these are certain signs that an opening exists in the membrane. Also, if the meatus be filled with warm water before inflation, the existence of a perforation will be demonstrated by the bubbles caused by the air escaping through the fluid. In some patients evidence of a perforation is yielded by the passage of tobacco-smoke from the throat into the meatus, and fluids injected into the latter canal sometimes pass into the pharynx, and even into the nose when the head is thrown forwards.

Another sign of a perforation is a pulsating movement in the secretion collected in the ear; it is most often noticed when the opening is small. The pulsating spots strongly reflect the light, and the movements consist in a rhythmical rising and falling or in lateral vibrations. They are due to the pulsations of the small arteries of the middle ear; the mucous membrane and the secretion which covers it rise and fall alternately. In very exceptional cases, similar movements are witnessed with an imperforate membrane, and it must be remembered that pulsation is sometimes observable in a deeply-seated abscess of the external meatus. It is possible that the pulsations of the carotid artery may be communicated to fluid accumulations within the tympanum.

Another method of detecting a perforation is to introduce a manometer into the meatus and then to inflate the tympanum: the fluid suddenly rises in the instrument. For this experiment to be successful, the Eustachian tube must be pervious to air, and the tympanum must be free from adhesions which would obstruct the passage of the current.

Prognosis.—This must always be guarded in cases of chronic middle-ear suppuration; the questions to be considered refer to the danger to life, the cessation of the discharge, and the improvement of the function of hearing. With regard to the first point, the risk of cranial complications must always be borne in mind, in spite of the fact that a large number of patients suffering from this disease never present any serious symptoms. A fatal result, however, may supervene when quite unexpected, and in an apparently simple case, with a history of otorrhœa of long duration. Under the influence of some external cause—*e.g.*, exposure to cold, a blow on the head, or an attack of naso-pharyngeal catarrh—the process may suddenly become acute, and severe pain in the head, rigors, fever, delirium, convulsions, and coma indicate the course the disease has taken.

With regard to the cessation of the discharge, the prospect is generally favourable in persons otherwise healthy, when the perforation is small and situated in the lower part of the membrane, when the naso-pharynx is not seriously diseased, and the Eustachian tube is patent. On the other hand, the prognosis is unfavourable when the discharge has continued for a long time, and when such local changes exist in the tympanum as granulations, polypoid growths, caries, or necrosis of the osseous walls. Abscesses in adjacent parts are serious complications. An obstinate form of the disease and a chronic course may be expected when a small perforation exists in Shrapnell's membrane, and when the upper part of the tympanum is mainly involved in the suppuration. The prognosis is decidedly unfavourable in cases resulting from scarlet fever, diphtheria, tuberculosis, and syphilis. Stricture of the Eustachian tube impairs the prospect of recovery, and thickenings or exostoses in the external meatus not only prevent the escape of secretion, but constitute serious obstacles to proper treatment.

The prognosis as to improvement in the hearing-power depends upon various considerations. It is favourable when the impairment of function is comparatively slight, when adhesions are absent, and improvement is noticed after cleansing the part and using the air-douche, and when the tympanic mucous membrane gradually regains its normal appearance. In some cases hearing-power is lessened with the cessation of the discharge; in others, a favourable result is witnessed, and even when the perforation is extensive. Improvement is likely to follow the removal of polypi and granulations, blocking up an opening in the membrane. The closure of a perforation by a cicatrix is not necessarily accompanied by improvement of hearing-power; if the newly-formed tissue be either very elastic or very rigid, the hearing-power may be less than before. The prognosis is unfavourable when the loss of function is considerable, when bone-conduction is lessened, and subjective symptoms continue troublesome. Under these circumstances, disorder of the labyrinth may be inferred to exist. Rigidity of the fenestræ and of the joints of the ossicles is another probable condition, tending still further to impede the conduction of sound and to increase the pressure upon the labyrinth.

Treatment.—Various measures are required for the satisfactory treatment of chronic middle-ear suppuration, the choice being determined by the nature of the symptoms and appearances. The first point to be attended to is the thorough removal of accumulated secretion and débris, which tend to promote suppuration and prevent the direct application of remedies to the diseased tissues. The middle ear may be cleansed in several ways. (1) Syringing through the external meatus in the ordinary way, or by the aid of a tube introduced through the perforation. (2) Inflation of the middle ear either by Politzer's method or by means of the Eustachian catheter, and in some cases by the injection of fluid remedies through the latter instrument. (3) Aspiration, with Siegle's pneumatic speculum. (4) Condensation of the air in the meatus. (5) Dry cleansing, by means of absorbent cotton-wool.

(1) The **Syringe** is used in the ordinary way, but especial care is necessary in making the first few injections. Very slight force must be employed, and if giddiness or pain be caused, the injections must be discontinued. From eight to twelve ounces should be used at each sitting, and the injections repeated according to the amount of secretion. If the latter be very abundant, the ear should be thus cleansed three or four times daily. When the discharge is profuse, obstinate, and blennorrhœic in character, good results may be obtained by adding four or five drops of oil of turpentine to the eight ounces of water used for injection. As micro-organisms are usually present in a discharge from the ear, the best lotions are solutions of biniodide and perchloride of mercury (1 in 1,000—1 in 2,000), or of carbolic acid (1 in 40

—1 in 80), but care must be exercised owing to the risk attendant upon the passage of the lotion into the pharynx. When a non-poisonous drug is required, izal may be used (1 in 200). A purer form than that usually sold is made for surgical purposes. To ensure the lotion being warm, it is most convenient to have the solution made double strength, and to dilute it with hot water. Peroxide of hydrogen (10 per cent.) or salicylic acid (gr. iv. Sp. Vini Rect. ʒij. Aquam ad ℥j.) may be used as drops in the following manner. The meatus is first to be thoroughly cleansed and dried with absorbent wool. The patient's head, with the affected side uppermost, is then made to rest on a pillow, and the solution is poured into the ear and allowed to remain for a few minutes. It is then removed and more fluid is poured in; this process is repeated several times. The meatus is then dried and plugged with cotton-wool.

Inspissated secretion in the mastoid cells is rarely found unassociated with the results of chronic suppuration in the tympanum and mastoid antrum; and as it can only be removed after the cells have been exposed, it must be taken away at the same time that the tympanum and the mastoid antrum are opened. The operation for dealing with this condition is described in Chapter XXXIII.

Syringing in the ordinary way will produce little, if any, effect upon accumulated masses of secretion in the tympanum, if the perforation be very small, especially if these be situated in the upper part of the tympanic cavity. For such cases it is necessary to employ a tympanic tube which directs the stream at a right angle to the meatus. Before using the irrigator, the meatus should be thoroughly cleansed by syringing, and it is well afterwards to render the membrana tympani and neighbouring parts less sensitive by the instillation of a few drops of a warm 10—20 per cent. solution of cocaine. The instrument* used by the author (Fig. 99) consists of a tapering silver tube seven-and-a-half-inches long, with a small aperture in its side close to the extremity of its lesser end. The larger end is connected by a piece of india-rubber tubing with a pipe which passes through a hole in the cork, almost to the bottom of the bottle which holds the solution to be injected. Through another hole in the cork passes a pipe, one end of which is above the fluid in the bottle, and connected to its other end is a piece of india-rubber tubing fitted with a mouthpiece. With this apparatus, the attic and entire cavity of the tympanum can be irrigated, and the force of the stream regulated by the expiratory effort employed. Most of the tympanic syringes hitherto in use are too large to pass through a small perforation, and they require an assistant to work them, as the surgeon's hands are occupied in holding the syringe and keeping the speculum in its proper position; moreover, they cannot be held motionless whilst the injection is being made.

---

* The instrument may be obtained from Messrs. Mayer & Meltzer, 71, Great Portland Street, London, W.

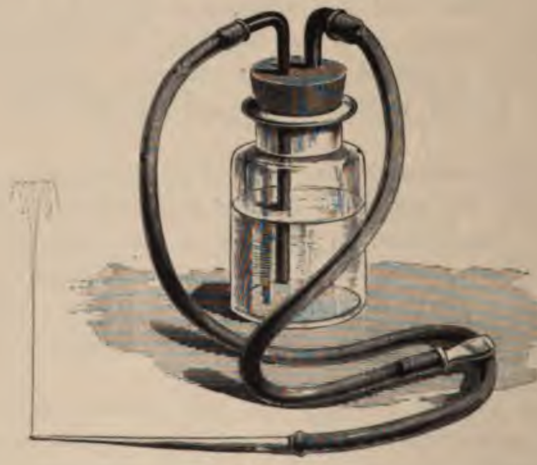


FIG. 99.

THE AUTHOR'S TYMPANIC IRRIGATOR.

In order to introduce the irrigator, the ear is illuminated with the forehead-mirror, and a speculum is passed into the meatus and kept in position with the left hand. The tube, taken in the right hand, is passed carefully through the perforation, and kept in position by resting the hand against the patient's head. Whilst the water or solution is being injected the tube is turned from time to time, so as to direct the current towards various parts of the cavity. If no uncomfortable sensations be produced, the irrigation is to be continued as long as any fragments of inspissated secretion come away. As a matter of course, the greatest care and gentleness are requisite in carrying out this treatment. The fluid should be injected very gently at first, and the force should then be gradually increased. Plain water may be employed in this manner; but the addition of bicarbonate of sodium (gr. iv. to ℥j.) will increase its efficacy.

(2) **Inflation of the Middle Ear**, by Politzer's method, has the effect of forcing out fluid secretion from the tympanum into the external meatus, and is of much value as a means of treatment in conjunction with syringing. The meatus should first be syringed, and then a Politzer's inflation given, after which some of the pus which was in the tympanum will be found forced out of that cavity. The ear should then be again syringed and another Politzer's inflation given, and these processes repeated alternately until the water which flows from the meatus is free from pus or mucus. The Eustachian catheter must be substituted for Politzer's method when the tube is blocked up by swelling and secretion, and when the cavity is filled with exudation products. Under such circumstances, the direct current of air is more efficacious than Politzer's method.

The Eustachian catheter may also be used for the injection of fluids into the middle ear. A large catheter should be selected, and its beak should be inserted as far as possible into the pharyngeal orifice. The fluid is injected by means of a syringe, the nozzle of which fits into the outer extremity of the catheter. Weak solutions of common salt ($\frac{3}{4}$ per cent.) or of boric acid (3 per cent.) are suitable for this purpose. The air-douche should be employed both before and after the injection of fluids. Air passing through the Eustachian tube acts especially upon the anterior part of the tympanic cavity; but has little influence upon secretion contained in the posterior recesses. To cleanse these latter parts, Politzer's method requires to be supplemented by the use of the tympanic irrigator as above described.

When the perforation is very small, thorough cleansing of the cavity by any of these methods may be found impossible, and it will then be necessary to enlarge the perforation or to make a second opening. An incision is likewise indicated when the perforation becomes prematurely closed, in which case symptoms due to the retention of the discharge are apt to supervene. A slight enlargement of the opening will enable a tube to be introduced and facilitate the escape of secretion.

The operation is easily performed with the paracentesis needle. The incision should not exceed one-eighth-of-an-inch in length, and should be carried through any projecting portion of the membrane. A few drops of a warm 20 per cent. solution of cocaine should be previously instilled into the meatus, and allowed to remain there for several minutes. (See page 351.)

It is sometimes desirable to make a second opening in the tympanic membrane, in cases of perforation of Shrapnell's membrane, when there are signs of accumulation of secretion on the floor of the tympanum, the lower part of the membrane being yellowish, and bulged out. A second opening not only facilitates the escape of secretion, but it permits fluids to be injected more freely into the cavity. Warm alcoholic solutions of boric acid and perchloride of mercury may be used in this manner, and good effects may be obtained from a watery solution of the latter drug (1 : 2,000) in cases in which the alcohol sets up irritation.

When obstinate suppuration is maintained by caries of the ossicles, and no effect is produced by antiseptic remedies applied through a suitable tube, the tympanum and mastoid antrum must be opened and the ossicles removed as described in Chapter XXXIII.

(3) **Siegle's Pneumatic Speculum** may be used to withdraw purulent secretion from the tympanum in cases in which the Eustachian tube is impermeable, and when the recesses of the cavity are filled with fluids which are not removed by any of the means above described.

(4) **Condensation of Air in the Meatus.**—This is effected by means of Lucae's apparatus, which consists of an india-rubber bag, furnished with an olive-shaped nozzle, which is inserted into the meatus. When the bag is compressed, the air is driven through the perforation into the tympanum and thence into the Eustachian tube, carrying with it more or less fluid secretion.

The current acts upon the anterior portion of the cavity and the tube. This plan of removing the secretion has been principally used for children, but it sometimes causes giddiness, and may be followed by more serious consequences.

Although this method has been often employed, it cannot be recommended, as, even with the greatest care, mischief is liable to result from its use. Moreover, not only does it possess no advantage over other means of removing discharge from the tympanum, but it entails the positive disadvantage of forcing pus into the patient's throat instead of effecting its complete removal. Unless the perforation in the membrana tympani is small, the inlet to the tympanum is obviously greater than the outlet, and, as the meatus is plugged by the nozzle of the syringe, the fluid which cannot escape by the Eustachian tube is forced into the mastoid cells and attic, and by this means the mischief which already exists may be increased.

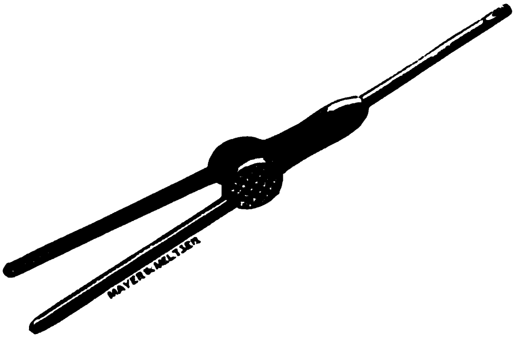


FIG. 100.

WOOL FORCEPS.

(5) **Cotton-Wool.**—Cleansing may to some extent be performed by means of absorbent cotton-wool, introduced on a holder or probe, or by means of suitable forceps (Fig. 100). This method is applicable to cases in which unpleasant symptoms are produced by syringing, and when the discharge is scanty and not offensive. It is insufficient for a thorough cleansing of the middle ear, and fails to effect the removal of inspissated matter from the recesses of the cavity. Cleansing with cotton-wool is especially useful as a supplement to fluid injections.

Antiseptic and Astringent Applications.—The methods above described are seldom sufficient to check the suppuration, and to induce a healthy condition of the tympanic mucous membrane. In most cases it is necessary to have recourse to remedies possessing antiseptic and astringent properties. Dr. Rohrer has shown that the fœtid character of the discharges in middle-ear suppuration is probably due to the presence of certain forms of bacteria; there is therefore a rational basis for the use of antiseptics. Owing, however, to the position and the peculiarly complicated structure of the middle ear, it is impossible to apply antiseptics to every portion of it. Still, experience shows that the best results are obtained from the use of remedies of that character, and especially from boric acid, which was first recommended by Dr. Bezold,* of Munich, in 1879. It may be employed either in solution, or as a fine powder, the latter being the more efficacious. It is applied in the following manner:—The meatus and tympanum are cleansed from secretion by syringing with an antiseptic solution, and inflating by Politzer's method alternately as previously described (page 447), and then carefully dried by means of absorbent cotton-wool. The boric acid, reduced to a very fine powder, is then blown into the meatus, by means of an insufflator (Fig. 59, p. 156), or with a glass tube or portion of a quill, and a plug of cotton-wool is finally introduced into the meatus. The author long ago discarded the wool-holders in general use, which are roughened in order to allow the wool to be more firmly attached. This roughening is unnecessary, and, moreover, possesses the disadvantage of preventing the wool, when done with, from being easily removed. He employs a plain straight piece of silver wire about five inches long, and attaches the wool in the following manner after it has been teased out. First place the end of the probe about the longitudinal centre of the piece of wool, then hold the proximal end of the wool to the probe with the right hand, whilst the probe is being twisted, and the wool pressed against the probe between the finger and thumb of the left hand. It will then be found to be firmly attached to the probe, and yet can be readily slipped off. The object of placing the end of the probe in the longitudinal centre of the wool is to ensure the distal half of the wool being soft by not being supported by the probe in its centre.

---

* For an account of Bezold's more recent experience of this treatment, see *Archives of Otology*, vol. xvii. p. 77; and *Ueberschau über den gegenwärtigen Stand der Ohrenheilkunde*, 1895, S. 144.

The frequency with which the powder should be used depends upon the amount of the discharge. If the latter be copious, the application must be repeated four or five times daily. Improvement is indicated by the lessening of the secretion; and when this is the case, a repetition of the treatment every second, third, or fourth day may be all that is necessary. In favourable cases, the discharge ceases after a few applications; but as a general rule the treatment has to be continued for several weeks, or even for some months. The deodorant and antiseptic effects of the powder are increased by the addition of carbolic acid (one drop to 15 grains), and when the discharge consists of stringy mucus, the addition of a few drops of oil of turpentine will prove advantageous. Powdered boric acid occasionally causes irritation, in which case a warm saturated solution should be poured into the ear several times a day, and allowed to remain there for a few minutes.

While this treatment is being carried out, the secretion should be frequently examined by the microscope, in order to discover whether any effect is being produced upon the development of micro-organisms. There is reason to believe that the presence of bacteria is the cause of the extension of the morbid process to the osseous walls and intra-cranial structures, and that antiseptic treatment is the best means of preventing such complications. If no decided improvement take place after the boric acid powder has been used for some weeks, a solution of the same drug in alcohol and water (Acid. Boric. ʒiiss.; Sp. Vin. Rect., Aq. Destill. aa. ℥j.), as recommended by Löwenberg, will sometimes produce a good effect. Löwenberg's opinion* is to the effect that this solution often proves more efficacious than the powder, inasmuch as it comes into contact with the whole expanse of the mucous membrane, whereas the powder fails to reach the many recesses of the cavity. If granulations or polypi exist in the tympanum or meatus, they must first be attended to in the manner to be shortly described. There are some cases in which the application of boric acid seems to have little, if any, effect in checking the suppuration. (1) In tubercular disease, in which it may be presumed that the boric acid fails to prevent the development of the bacilli. (2) When the perforation is very minute: in such a case it is desirable slightly to enlarge the opening. (3) When the perforation is situated in Shrapnell's membrane, a saturated solution, introduced through the intra-tympanic tube, is likely to prove more efficacious than the powder. (4) The existence of carious or necrotic fragments of bone will maintain the suppuration, and neutralise the effects of the boric acid.

---

* Quoted by Knapp, *Archives of Otology*, vol. xi. p. 223.

Other antiseptic remedies may be substituted if the treatment by boric acid prove unsuccessful. *Carbolic acid* may be used in various forms, *e.g.*, 1 : 10 of glycerine, of which a few drops may be placed in the ear. If pain be caused, a weaker solution should be tried, *e.g.*, 1 : 15 of rectified spirit, and a like quantity of water: 15—20 drops to be warmed and instilled into the ear. Much irritation is, however, sometimes caused by carbolic acid. *Iodoform* is much employed by some surgeons; Dr. Barr, of Glasgow, recommends that half a drachm be added to an ounce of spirit of wine, in which it is partly dissolved and partly suspended. After the mixture has been well shaken, fifteen drops are poured into the ear, and allowed to remain for fifteen minutes, after which the ear is dried with cotton-wool. Some of the spirit evaporates, and leaves a coating of iodoform on the diseased surface. Dr. Barr states that a few applications of this remedy have cured cases in which other treatment, persevered with for a whole year, had proved useless. It is especially suitable for cases of perforation of Shrapnell's membrane, and is most thoroughly applied by means of the tympanic tube. It may also be used in the form of powder in combination with boric acid (1 to 4), as recommended by Dr. Barr. The disagreeable odour of the drug may be masked by the addition of a little tincture of Tonquin beans to the spirituous solution, or of one grain of coumarin to fifty of the powdered iodoform. The objection to this treatment, if long continued, is that the iodoform is liable to collect in the recesses of the tympanum, and remain there, as it is only sparingly soluble in water, and therefore does not become dissolved and absorbed. Besides this drawback, the application of iodoform causes, in some patients, severe eczematous inflammation of the external meatus. *Iodol* is another remedy of the same class, which may be employed as an alcoholic solution (1 : 20).

Salicylic acid may be used either in an alcoholic (2—5 per cent.) or an aqueous solution (1 : 200). More or less irritation is apt to ensue when a strong solution is employed. A combination of salicylic and boric acids (1 to 10—15) is sometimes more efficacious than either used separately. *Biniodide* and *perchloride of mercury* are also valuable antiseptic remedies and powerful germicides. They may be used in an aqueous solution (1 : 1,000), of which 15—20 drops are to be instilled into the ear. A solution of similar strength, but made with equal parts of water and rectified spirit, is generally more efficacious, but it is apt to cause irritation. If no improvement be noticed after a fortnight's use of the biniodide or perchloride, some other form of treatment should be adopted, and the same rule holds good with regard to the other remedies previously mentioned. It is necessary to be provided with a somewhat long list of remedial measures, inasmuch as the treatment which has proved successful in one case may be found almost useless in another. A 10 per cent. solution of *peroxide of hydrogen* may be poured into the ear, and allowed to remain for some minutes. Instillations of *boroglyceride* (a 10—50 per cent. solution) may be used in cases of otorrhœa. To complete the list of antiseptics used and recommended for the treatment of chronic middle-ear suppuration, it is necessary to mention *resorcin* (a 4 per cent. spirituous or aqueous solution): *thymol* (1 : 100); finely powdered (doubly sublimed) *calomel* by insufflation;* *borax* in solution, either alone or combined with 5 per cent. of *salicylic acid;* and *permanganate of potassium* (4 : 1,000).

If treatment by boric acid and other antiseptics prove unavailing, other remedies must be tried. Caustics are often useful in obstinate cases, with extensive destruction of the tympanic membrane, muco-purulent secretion, and relaxation and swelling of the mucous lining. Chromic acid in solution (5 to 15 grains to the ounce) is very useful; or a strong solution of nitrate of silver (20 to 60 grains to the ounce) may be employed instead; but the latter must be used with certain precautions. The meatus in both cases must first be cleansed, and thoroughly dried. When nitrate of silver is used it is well to have a warm weak solution of common salt at hand. From 5 to 10 drops of the caustic solution, warmed, are dropped into the ear from a glass pipette, the patient lying down and with the affected ear directed upwards. The caustic may be allowed to remain for three or four minutes, after which water or the saline solution should be injected; but recourse must be had to this treatment immediately if severe burning pain be experienced. The relief is generally immediate, but should the pain continue after the application of nitrate of silver, the ear should be syringed out with a weak solution of iodide of potassium. The meatus should then be carefully dried and plugged with cotton-wool.

---

* See a paper by Dr. Gottstein, of Breslau, *Archives of Otology*, vol. xiii. p. 284.

The immediate result of the application of nitrate of silver is the formation of a white pellicle, which is sooner or later thrown off, exposing the red mucous membrane. In most cases, it will suffice to repeat the treatment every second day until seven or eight applications have been made. In cases in which the granulations are large and soft, and bleed freely when touched with a probe and when water is injected into the meatus, it is best to apply a saturated solution of chromic acid on a carrier (Fig. 82, page 283). When solid nitrate of silver is used, the caustic is fused in a porcelain crucible and the probe dipped into it. In touching the granulations, care must be taken to obtain a good view of the wall of the tympanum and of the remains of the membrana tympani. It will sometimes be found that a small ulcer exists in the deep part of the cavity, and that a few applications of the solid caustic will produce cicatrisation. To prevent excessive action, water or the saline solution should be injected, as before.

For cases similar to those just described, the application of rectified spirit of wine sometimes proves very advantageous. It is said to act by withdrawing water from the granulations. The undiluted spirit is apt to cause severe pain and irritation, and therefore it should at first be diluted with an equal quantity of water. About 15 to 20 drops of this mixture are warmed and poured into the meatus, and allowed to remain for about a quarter of an hour. The fluid is then removed and the ear carefully dried. The application may be made daily, or every other day, the strength of the mixture being gradually increased, if little or no pain be experienced. Lessening of secretion and a paler tinge of the mucous membrane are indications that the alcohol is producing a beneficial effect. As holds good with regard to all other applications to the tympanic cavity, if the alcohol cause pain, headache, giddiness, or other uncomfortable sensations, its use must be discontinued. It often acts very satisfactorily, and has this advantage, that under proper precautions the patient or his friends may be entrusted with its use.

Solutions of pepsin and papain have been recommended as rapid solvents of cicatricial tissue, filaments, and bands, the result of chronic suppuration. (For the manner in which pepsin is used in adhesive inflammation, see page 385.) For chronic suppuration, 15 minims of a 5 per cent. solution of papain, warmed, should be dropped into the ear. The patient is then told to swallow, with the nostrils closed, and the fluid is thus drawn into the middle ear. The solution is said to be improved by the addition of 2½ per cent. of bicarbonate of sodium.

Astringents constitute a class of remedies which at one time were very generally used in the treatment of otorrhœa; their efficacy is far inferior to that of boric acid and other antiseptics. Those still occasionally employed are sulphate of zinc, sulphocarbolate of zinc, acetate of lead, acetate of zinc, alum, and sulphate of copper; they are applied either in solution or in the form of fine powders. Pain in the ear, or any other symptom indicative of an acute process, contra-indicates their employment, and all of them are liable to the objection that they form insoluble albuminates with the secretions in the tympanum. Alum is, perhaps, the most efficacious; but it should be reserved for cases of large perforation, and should not be tried until boric acid has been used without avail. Its use must not be entrusted to the patient, for the powder is apt to form a solid plug in the deep part of the meatus and thus to prevent the escape of secretion. It is also liable to irritate the integument of the auditory canal, and to cause much pain and even inflammation, which cannot fail to aggravate the original disease. When used, only a small quantity must be insufflated, and any of the powder which adheres to the skin of the meatus should be removed with a camel-hair brush. The application may be repeated when the coating formed by the alum appears moist: careful syringing and drying with cotton-wool should precede each insufflation. If no satisfactory result be obtained after six or eight applications, some other method of treatment must be adopted. Acetate of lead (gr. iv.—℥j.) is occasionally serviceable, and is the least irritating of this class of remedies. From 15 to 20 drops of this solution are made warm and instilled into the meatus, the patient's head being kept in a horizontal position. The solution is allowed to remain for about ten minutes, and then removed, and the application is to be repeated daily or every other day. Preparations of lead thus applied cause the mucous membrane of the tympanum to assume a dark-grey colour, and thus mask its real condition. In some cases the discharge becomes decidedly black or blackish, the change being due to the formation of the sulphide of lead, and indicating decomposition of the secretion. Under such circumstances, treatment by means of antiseptic remedies should at once be adopted. The preparations of zinc and copper are of comparatively little value in the treatment of chronic middle-ear suppuration. If used, they are applied in the form of solutions of the sulphate (gr. ii.—iv. to ℥j.) in the same manner as the acetate of lead. Dr. Knapp* recommends the sulpho-carbolate of zinc, 1 or 2 parts to 50 parts of alcohol and 50 parts of water.

When a large perforation exists, and also in cases of otorrhœa with only a scanty discharge, Urbantschitsch† recommends the employment of gelatin bougies, containing such astringents as acetate of lead, tannin, sulphate of copper, sulphate of zinc, etc. He prefers these to solutions, but restricts their employment to the classes of cases above mentioned. Whenever the secretion is profuse, it is undesirable to create any obstacles to its free escape. Urbantschitsch reports very good results from mercurial preparations thus applied. He uses thin tablets, which can be cut into fine strips, and then passed through small perforations in the tympanic membrane.

Of all the methods of treatment which have just been described, that by boric acid will be found to be more generally suitable and successful than any other. If however, after a thorough trial, continued for five or six weeks, little or no improvement result, another remedy should be tried; and the choice will usually lie between occasional applications of a solution of chromic acid or nitrate of silver (either in substance or solution), and daily treatment by rectified spirit of wine (either alone or combined with boric acid). It is often necessary to try several remedies in succession before a satisfactory result is obtained; and in some cases success is achieved only by a combination of remedies. Thus after boric acid and caustics have failed when separately employed, a cure may result from insufflations of the former drug after application of the nitrate of silver.

---

* *Archives of Otology*, vol. xi. p. 222.

† *Lehrbuch der Ohrenheilkunde*. III. Aufl. S. 323.

In all cases of chronic middle-ear suppuration, the greatest importance must be attached to constitutional treatment and attention to hygienic measures of all kinds; and the condition of the naso-pharynx must be carefully and repeatedly examined, and means adopted to remove any abnormal condition. It is useless to apply remedies to the tympanic cavity, if a chronic naso-pharyngeal catarrh, the source of the aural complaint, remain unchecked. So likewise in cases of constitutional disease, *e.g.*, syphilis or tuberculosis, unless general treatment be superadded to the local measures, a good result can scarcely be expected. Conditions of general debility and of anæmia will also require attention; iron, quinine, nourishing food, cod-liver oil, fresh air, change of air to the seaside, baths, and hygienic measures of all kinds are often indispensable adjuncts to any method of local treatment. The inhalation of oxygen* for several hours daily has been followed by marked improvement in some cases of middle-ear suppuration. It must, however, be regarded only as a supplement of other remedial measures.

In order to complete this description of the treatment of chronic otorrhœa, it is necessary to refer to certain measures whereby the hearing-power may often be improved. These are: (1) Inflation of the middle ear; (2) rarefaction of air in the meatus; (3) the adaptation of an artificial tympanic membrane; (4) operations of various kinds. Of these only the two first will now be referred to; the others will be more appropriately discussed in the next chapter.

1. Politzer's method is best adapted for the inflation of the middle ear in these cases; it should be employed twice or three times a week, and continued during four or five weeks after the discharge has ceased, unless its employment is likely to break down a cicatrix which is forming or one which has formed across

---

* "Cases of Diseases of the Nose and Ears treated by means of Oxygen Gas," by Dr. G. Stoker, *Journal of Laryngology, Rhinology, and Otology*, March, 1896.

the perforation which previously existed. In this case, an Eustachian catheter should be used, the injecting force being merely sufficient to enable the air to enter the tympanum. If the discharge is more than slight, or even then does not quickly disappear, the combination of Politzer's inflation with syringing for the purpose of thoroughly cleansing the middle ear, as before described, should not be neglected.

2. Rarefaction of the air in the meatus is not only useful in the secretory stage, when the tube is impervious, and in cases of circumscribed suppuration in the tympanum, but it likewise tends to improve the hearing-power, after all discharge has ceased. Improvement, though only of a temporary character, has been observed even in cases of adhesion of the tympanic membrane to the joint between the incus and stapes, when inflation through the tube was without effect. Rarefaction of the air in the meatus, with either Siegle's or Delstanche's (Fig. 101) instrument, is always worthy of trial. Reference has already been made to Hommel's method and to the use of Lucae's spring-probe (see page 387).

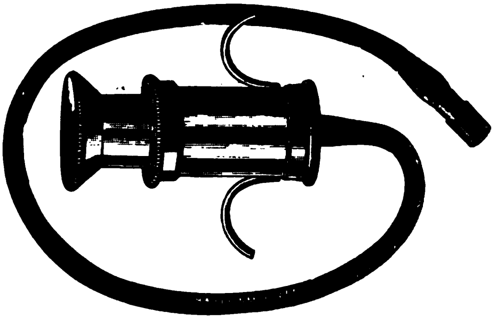


FIG. 101.

DELSTANCHE'S MASSEUR.

It would appear, from certain facts that have come under the author's notice, that persons suffering from chronic suppurative inflammation of the middle ear may be a source of danger to others. A medical practitioner, thus affected, attended several women during their confinements. Intervals of several weeks elapsed between the attendances; but all the women were attacked by puerperal fever. No cause could be discovered, and the medical man was led to suspect that the discharge from his own ear had produced the mischief, and he ceased to attend cases of midwifery. Granted that his suspicions were well founded, it is probable that the septic matter was conveyed by his fingers; and the question must arise as to whether a practitioner or nurse suffering from chronic suppuration of the middle ear is justified in attending cases of midwifery, and likewise surgical cases requiring the application of dressings, etc.

CHAPTER XXIX.

CHANGES IN THE MEMBRANA TYMPANI IN VARIOUS AFFECTIONS OF THE EAR.

Cicatrisation—Persistent Perforation of the Tympanic Membrane—Appearances and Consequences—Artificial Substitutes—Method of Determining Effect of Closing a Perforation—Treatment of Perforations—Attempts to Produce Cicatrisation—Myringo-Plastic Operations—Artificial Tympanic Membrane—Appliances devised by Yearsley, Toynbee, Gruber, Hartmann, and Others—Rules to be Adopted—*Modus Operandi* of such Appliances—Indications for Employment of Artificial Membranes—Calcareous Deposits in the Membrana Tympani—Appearances—Symptoms and Treatment—Thickening of the Tympanic Membrane—Atrophic Processes in the Membrane—Adhesions between the Membrane and the Wall of the Tympanum.

It seems desirable to give a connected account of those various abnormal conditions of the tympanic membrane which result from affections of the middle ear, and most frequently from suppurative inflammation. These conditions may be considered under the following heads: (1) cicatrisation; (2) persistent perforation; (3) calcareous formations; and (4) adhesions between the membrane and other structures of the tympanum.

(1) **Cicatrisation.**—Solutions of continuity of the membrana tympani, in the form of small slits and attended only by slight and transient inflammation, may unite directly by simple union. But under different circumstances, when the opening is large, and retraction or destruction of the membrana propria has taken place, healing becomes possible only with the formation of a cicatrix. In this latter process, the membrana propria takes no share; the new tissue is formed by proliferation of the epithelial

and connective tissue cells of the cutaneous and mucous layers. The cicatrix, therefore, consists of a delicate layer of connective tissue, coated externally by a thin epidermis, and internally by a single stratum of the flat epithelium-cells of the membrana tympani. The cicatrix is therefore thinner than the normal membrane; when illuminated with the mirror it is seen to be more transparent than the adjacent part, and is bright or dark according as it approaches the inner wall of the tympanum or is withdrawn from it. As a general rule, its lessened thickness causes it to be somewhat below the level of the rest of the membrane. The fibres of the membrana propria frequently terminate at the margin of the cicatrix, as if cut off abruptly; but sometimes they are bent upon themselves and run for some little distance in an opposite direction. Occasionally it is possible to detect in the middle of a cicatrix an oval pearl-like mass of epithelium, covered with a layer of epidermis.

With regard to the *colour* of cicatrices of the tympanic membrane, when small and situated opposite the promontory, they are clearer than those which are found in the anterior inferior quadrant. A depressed cicatrix, which is near to the wall of the tympanum, may be of a light-brown colour. Cicatrices are always more highly tinted than the adjacent parts of the membrane, and the difference is often increased by the whitish coloration of the latter portions.

Cicatrices in the membrana tympani are for the most part well defined; sometimes there is a decided reflex of light, of varying form and dimensions. A sharply-defined border is, however, sometimes noticed as bounding small atrophic spots on the membrane; but when a history of otorrhœa is forthcoming, there can be little doubt as to the nature of the case.

Cicatrices of the membrana tympani vary in *size*, for large perforations are as capable of closure as small ones. They are most often seen in the lower half of the membrane; their form varies according to that of the original orifice. In many cases they appear as sac-like depressions and involutions of the membrane; in other cases their inner surface is connected, either directly or by strands of connective tissue, with the wall of the tympanum or the ossicles, and especially with the long process of the incus and the head of the stapes. Large cicatrices, owing to their transparency, often allow the inner wall of the tympanum to be clearly seen, and, in many cases, are so closely applied to this part, that the appearance is that of total loss of the membrane. As the result of atrophy and diminished resistance, the entire membrane, or certain parts of it, become much relaxed, and move freely under the influence of variations of pressure. These movements are visible if the ear be examined during expiration and inspiration, during swallowing movements, and especially when air is forced into the tympanum by Valsalva's method, or with the aid of the catheter. As a general rule, during inspiration the membrane moves towards the tympanic cavity, and in the opposite direction during expiration.

During inspiration, the air in the naso-pharynx becomes momentarily rarefied, and this action is reinforced by the effect of the air-current upon the pharyngeal opening of the tube. The air is thus drawn towards the throat, and the diminution of pressure in the tympanum causes the membrane to be drawn inwards. When expiration follows, the air in the naso-pharynx is condensed, and this effect is transmitted through the Eustachian tube, so that the membrane is again forced outwards.

During the act of swallowing, the relaxed portion of the membrane moves slightly but rapidly inwards, then more decidedly outwards towards the meatus, and then again inwards. As the tube is opened by the act of swallowing, the air passes from the middle ear to the throat, and hence the short movement occurs in an inward direction. The movements outwards and then inwards are consequent upon the condensation and rarefaction respectively of the air in the middle ear caused by the elevation and depression of the pharynx and base of the tongue.

When air is artificially forced into the tympanum, the relaxed portions of the membrane either become slightly convex or bulge out like little sacs or bladders; if the relaxed portion or cicatrix involve the greater part or the whole of the membrane, it becomes distended, like the belly of a sail. If the pressure be sufficient, the relaxed part may give way, when a loud noise is heard and the patient complains of pain. On examining with the speculum an opening is seen, varying in size, but with retracted border, marked with recent extravasation of blood.

When Siegle's speculum is used, the cicatrix or atrophied portion of the membrane, unless adherent to the inner wall of the tympanum, moves to and fro, in accordance with the alternations of pressure in the meatus.

Pulsating movements are sometimes observed; these arise in the arteries of the inner wall of the tympanum, and are communicated either directly to the closely applied and relaxed portion of the tympanic membrane, or through serous exudation in the cavity.

It must be remembered that a perforation sometimes undergoes only partial cicatrisation. When the opening is large, membranous formation may be confined to one part, so that perforation and cicatrisation coexist. In large perforations in the neighbourhood of the umbo, the end of the handle of the malleus is not always included in the cicatrix, but projects behind it into the tympanic cavity, attached, if at all, to the membrane only by strands of connective tissue. When this is the case, the condition of the parts can usually be made out by the aid of Siegle's speculum.

It seldom happens that cicatrices in the tympanic membrane give rise to any symptoms appreciable by the patient. When, however, they are large and much relaxed, and when they are drawn inwards and adherent, the patient may complain of noises in the ears and more or less deafness. Less frequently there is a sensation of fluttering or undue movement in the ears, noticed especially during inspiration and expiration.

Cicatrices in the membrana tympani rarely demand any kind of treatment. Something may be done, however, for the relief of deafness associated with relaxed and indrawn cicatrices. For such a condition Politzer recommends multiple incisions, either parallel or crossing each other. These, on healing, sometimes produce thickening with increased resistance, and consequent diminution of the symptoms. As a temporary measure, for the relief of symptoms dependent upon an indrawn cicatrix of the membrane, the air-douche may be tried with advantage; but the frequent employment of this method, and still more of Valsalva's plan, is likely to cause undue relaxation and mobility of the cicatrix.

(2) **Persistent Perforation of the Membrana Tympani.**—Gruber* has met with a case of congenital aperture

---

* *Journal of Laryngology, Rhinology, and Otology*, April, 1895, p. 313.

in the tympanic membrane, complicated by obliteration of the orifice of the Eustachian tube. Such cases are very rare; but as a result of long-continued or repeated attacks of suppuration in the middle ear, a large perforation of a permanent character not infrequently ensues. A certain amount of contraction may take place, but an aperture remains, the margin of which is usually thickened, owing to increase of connective tissue and calcareous deposit, which often gives it a whitish tint. The epidermis of the membrana tympani is continued over the margin of the opening to its inner border, and sometimes covers the greater portion of the internal surface, and may extend even to the walls of the cavity.

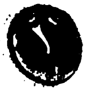


FIG. 102.

THE LEFT EAR of a girl, aged 17 years, who has had suppurative inflammation. Through the perforation in the posterior segment can be seen a portion of the long process of the incus and the head of the stapes.

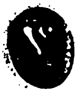


FIG. 103.

THE LEFT TYMPANIC MEMBRANE of a girl, aged 17 years, showing considerable loss of the membrane as a result of suppurative inflammation, but the ossicula remaining in their relative position.

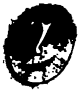


FIG 104.

THE RIGHT MEMBRANA TYMPANI of a young woman, aged 22 years, showing a large perforation in the posterior segment, and below its upper border the tip of the long process of the incus and the head of the stapes.

The *shape* of the opening varies in different cases; its most common seat is the lower half of the membrane. Sometimes two perforations coexist, one in the anterior and the other in the posterior inferior segment; these are separated from each other by the handle of the malleus and by a narrow strip of the original tissue extending from the extremity of the bone towards the periphery. Sometimes the loss of substance involves the larger part of the membrane, only a narrow border being left at the circumference (Fig. 103). The portion that remains is often more or less dull, either thickened or atrophied, and coated with calcareous deposit (Fig. 105). It seldom happens that the membrane is totally wanting. According to the position and size of the perforation, various structures contained in the middle ear are more or less freely exposed to view (see Figs. 102, 103, 104, 105, and 107).

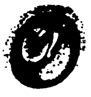


FIG. 105.

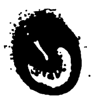


FIG. 106.

Fig. 105. THE RIGHT EAR of a young woman, aged 24 years, who had chronic suppurative inflammation. There is a perforation in the posterior segment, through which can be seen the tip of the long process of the incus and the head of the stapes. A patch of calcareous deposit occupies the greater portion of the anterior segment.

Fig. 106. THE LEFT EAR of the same patient, showing a large patch of calcareous deposit.

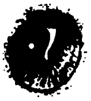


FIG. 107.

THE RIGHT EAR of a woman, aged 31 years, showing a perforation in the posterior segment, through which can be seen the stapes, which has become disarticulated from the incus, and its head in consequence has dropped downwards. There has been also a perforation in front of the short process of the malleus, but adhesions have formed between its edge and the deeper parts.

Other appearances and consequences depend upon the size and position of the opening. Cases are often met with in which, notwithstanding very considerable loss of substance, the hearing-power is relatively good. It may, therefore, be inferred that marked loss of function, when present, is largely due to impediments to conduction connected with the ossicles, or to obstruction of the fenestræ. Pathological changes of this kind are due to the disease which caused the perforation, and those most often met with are: retraction of the handle of the malleus, sometimes to such an extent as to cause the bone to become adherent to the inner wall; adhesive processes between the latter part and the margin of the perforation; ankylosis, displacements and exfoliation of the ossicles. More important as regards their influence on the hearing-power are formations of connective tissue and calcareous deposits in the fenestræ. The existence of a perforation in the membrana tympani favours the access of micro-organisms and other sources of mischief, and hence increases the liability to recurrences of attacks of inflammation.

It sometimes happens that even large perforations, after remaining quiescent for several years, suddenly begin to diminish in size, and eventually are covered in by cicatrices. This process has been observed to take place under the influence of a slight attack of inflammation, and its occurrence has stimulated the desire to produce a similar result by artificial means.

Before proceeding to describe the various methods of forming an artificial membrana tympani, it is well to consider the difficulties that have to be overcome and the prospects of success. As already stated, the question whether the hearing-power will be improved by the closure of a perforation and the production of a cicatrix must depend upon the condition of the other portions of the sound-conducting apparatus. If the condition of the malleus or incus constituted a permanent obstacle to the conduction of sound, the formation of a cicatrix would tend only to impair the hearing-power. Sonorous undulations which passed through the perforation direct to the foot-plate of the stapes, would, after the development of a cicatrix, be communicated to the malleus and incus, and their intensity would be diminished by the obstacle therein existing. Politzer has suggested a method of determining whether the closure of a perforation would have any effect upon the hearing-power. The amount existing in an ear in which the membrane is perforated is determined by careful examination: the opening is then closed by a drop of glycerine or a small piece of paper, and the hearing is again tested. If the sounds be less distinctly heard, an obstacle to conduction, connected with the malleus or incus, may be inferred to exist.

As a general rule, perforations of the tympanic membrane with relatively good hearing-power are best left alone. When, however, the defect is bilateral and a marked degree of deafness co-exists, it becomes desirable to take steps to close the opening. The good effects of such an alteration are sometimes very evident; their discovery was first made by patients themselves, the subjects of perforation, who found their hearing-power improved when a roll of paper was passed deeply into the meatus for the purpose of removing secretion. Politzer states that the use of an artificial membrana tympani was known as far back as 1640.* It was, however, only about the middle of the present century that the plan became used by a few aural surgeons, and notably by Yearsley, Erhard, and Toynbee. Before describing the various appliances used by them and their successors, reference will be made to the plans adopted with the view of causing the openings to close.

One simple plan is that of stimulating the edges of a perforation by applying nitrate of silver. The caustic is fused, and a small portion is then taken up on the head of a probe; or a piece of cotton-wool twisted tightly on to a probe and moistened with a strong solution of the same drug, may be applied to the edges of the opening. With small perforations this plan sometimes proves successful, but it involves the risk of setting up too much irritation, with suppuration and enlargement of the opening as probable results. The same drawbacks are associated with the use of the galvano-cautery, or the knife, for the removal of tissue at the edge of the perforation. This plan is spoken well of by Gruber,† who also recommends for small perforations numerous incisions ½ — 1mm. in length, made quite close to one another, and at right angles to the margin of the perforation. The operation causes only slight pain and hæmorrhage. Gruber states that small perforations, even of long standing, treated in this way, often close up, and larger ones diminish in size. The experience of other surgeons is, however, less favourable. In some cases of dry perforation, division of the tensor tympani tendon is followed by partial or complete closure of the opening; and removal of the malleus, when the handle seems foreshortened, increases the effect of the operation on the tendon.

Many attempts have been made to utilise portions of skin and various membranes in order to cover up the perforation, but hitherto without any decided amount of success. The first surgeon to perform this myringoplastic operation was Prof. Berthold,* of Königsberg. He first applied a piece of court plaster (which was allowed to remain for three days) in order to remove the epidermis. He then detached a portion of skin from the patient's forearm and applied it to the opening, the edges of which it overlapped. The external meatus was afterwards plugged with cotton-wool. Subsequently Berthold used a portion of egg-membrane for the same purpose. A very fine glass-pipette, bent at an angle of 125°, and fitted with an ordinary piece of india-rubber tubing, closed at the further end, was used for the introduction. The mouth of the pipette was dipped in white of egg, and a small piece of the egg-membrane aspirated on to it with the moist inner surface outermost. The membrane adheres to the mouth of the pipette, and can thus be conveniently trimmed into shape. It is then conveyed to the required position on the tympanic membrane, to which it is made to adhere by compressing the india-rubber tube. It soon becomes closely united with the edge of the perforation, and it may remain for weeks or months, but the effect is never permanent.

---

* Marcus Banzer, *Disputatio de Auditione Læsa*, 1640 (cited by Politzer, S. 346).

† *Lehrbuch der Ohrenheilkunde*, II. Aufl. S. 362. (Professor Gruber's death was announced while these pages were being printed.)

Since 1888 Berthold† has returned to his first plan of utilising the integument, but he applies it not to the remains of the tympanic membrane, but to the mucous membrane. After suppuration has ceased, and he has loosened any adhesions between the edge of the perforation and the opposite wall of the tympanum, he places on the granulating mucous surface of the promontory a piece of skin precisely the size of the perforation, and of a thickness equal to the distance between the margin of the latter and the inner tympanic wall. The piece of skin fits into the margin of the perforation, as a watch glass into the groove of the rim. The granulating mucous membrane affords the material for the nourishment of the transplanted skin, whilst the latter is attached to the edges of the perforation by the secretion which oozes out. Transplantation with human skin proved successful, in Berthold's hands, in closing over the largest perforations, and even in cases in which the tympanic membrane had been completely destroyed. One drawback connected with this method is due to the uncertainty as to whether union will take place, and the difficulty of selecting the proper time for the operation. If the mucous membrane were still secreting, the continuance of the suppuration would almost certainly prevent adhesion. If, on the other hand, suppuration had ceased, the mucous membrane would have a coating of epithelium, which would prove an obstacle to union. Moreover, in the hands of some surgeons, this method, although successful so far as regarded closure of the perforation, resulted in more or less diminution of hearing-power.

---

* *Tagebl. d. 51, Versammlung Deutscher Naturforscher und Aerzte*, Cassel, 1878.

† *Archives of Otology*, vol. xx. p. 371.

The Artificial Tympanic Membrane.—As already stated, an English surgeon, Mr. Yearsley, was the first to call attention to the improvement in hearing which can sometimes be produced by applying a little plug of cotton-wool over a perforation in the tympanic membrane (Figs. 108, 109). Since his time many attempts have been made to discover more efficacious contrivances, and a considerable amount of success has been attained. The objects aimed at, and the modes in which the various appliances act, differ to some extent in character. By some the vibrating surface of the membrane is increased, if not restored to its original amount, while at the same time pressure is exercised on the remains of the membrane and the ossicles connected therewith. If also the handle of the malleus be much drawn inwards, pressure upon the short process overcomes this condition and causes a movement of the ossicles in an outward direction.

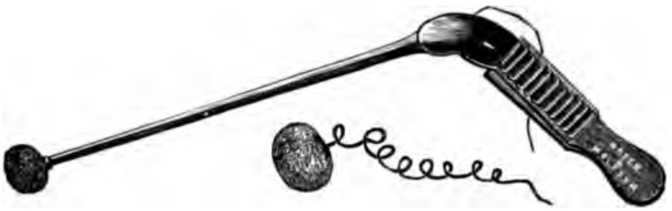


FIG. 108.
YEARSLEY'S TYMPANUM.

FIG. 109.
INTRODUCER FOR YEARSLEY'S TYMPANUM.

Not long after Yearsley advocated the cotton plug, Toynbee devised an artificial drum, consisting of a disk of vulcanite india-rubber, 6—7mm. in diameter. Attached to its middle is a piece of silver wire, about $1\frac{1}{4}$ inches in length (Fig. 110). The disk is cut to fit the meatus, and, when moistened, is easily introduced by taking the free end of the wire between the fingers, drawing the auricle backwards and upwards, and then pushing the disk along the meatus until it meets with resistance. In some patients, however, the wire handle causes uncomfortable sensations or irritation in the meatus, and it may become detached, hence a thread has been used instead of the wire (Fig. 111), and various modifications of Toynbee's appliance have been suggested. In place of the wire, Lucae has a fine india-rubber tube connected with the disk, and insertion is effected by the aid of a probe filling the tube. Gruber[*] has designed a somewhat elaborate but effective apparatus, by means of which the patient can construct the artificial membrane. The apparatus consists of a vulcanite case containing needles, silk thread, and a suitable sheet of gutta-percha tissue. The end of the case contains a punch, corresponding to the size and shape of the normal tympanic membrane. By this instrument a disk is punched out of the gutta-percha and threaded with silk through the centre. A simple instrument is employed for the introduction of the artificial membrane. It is a piece of wire curved round to form a small ring, which is bent at a right angle to the shank. The other end is bent to form a larger ring. To insert the disk, the thread is passed through the small ring and along the wire, being kept in contact with this by the finger. When the disk has

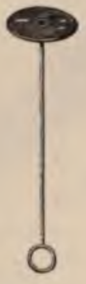


FIG. 110.

TOYNBEE'S ARTIFICIAL TYMPANUM.

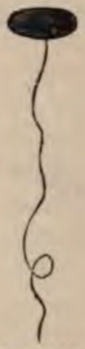


FIG. 111.

TOYNBEE'S ARTIFICIAL TYMPANUM, WITH THREAD INSTEAD OF WIRE.

---

[*] *Lehrbuch der Ohrenheilkunde*, S. 364.

been properly adjusted in its place, the thread is released and the wire is withdrawn. A pair of bent forceps may also be used for the introduction of the artificial membrane. Linen, silk, or paper may be used in place of the gutta-percha. Dr. Katz* recommends a thin pellicle of celloidin (celloid 10, alcohol and ether aa. 50); this is applied by means of a plug of wool dipped in the solution.

Another convenient contrivance is that devised by Dr. Hartmann.† It consists of a small portion of cotton-wool, twisted into a round ball and continued into a thin process, around which a thread is carried: the whole is impregnated with a solution of wax. Delstanche has devised an equally simple contrivance. He takes a small piece of soft wire, which he bends at one end. Around this wire the cotton-wool is wrapped in such a way as to form a little ball at the end, while the rest of the wire is covered only with a thin layer of wadding. Politzer has suggested a more durable contrivance. This consists of a piece, half a centimetre long, cut from the side of an india-rubber tube 2—3mm. thick; the lower end is perforated and fixed to a moderately strong wire. Good results can also be obtained from the introduction of a piece of india-rubber tubing, adapted to the length of the meatus, and having its inner extremity either rounded off or cut obliquely. The same authority recommends another contrivance, viz., a combination of Toynbee's membrane with a stapes bone, taken from a dead body, for cases in which the crura have been destroyed by erosion, and only the base of the bone is present in the fenestra ovalis. The ossicle is fastened by thread to the india-rubber plate, and, when introduced, is directed towards the niche of the fenestra ovalis. The waves of sound are conveyed from the disk to the foot-plate of the stapes, and thence to the labyrinth.

It would seem that on the whole the best substitute for the natural tympanic membrane is a cotton-ball or pellet impregnated with boric acid, salicylic acid, or thymol, and then moistened with diluted glycerine (1 : 4 Aq.). It is well to attach a piece of thread to the pellet, so that it may be easily removed. Cotton-wool causes little, if any, irritation, and has the further advantage of absorbing secretions. In some cases two or three layers of lint, cut to the requisite size and shape, answer better than the pellet of cotton-wool. It must be remembered that different appliances are suitable for different patients, and it is therefore well to be provided with several forms.

---

* *Deutsche Med. Woch.*, 1889, Nr. 28.

† *Diseases of the Ear*, English Translation of 3rd Edit., p. 118.

Any form of artificial substitute for the membrana tympani requires renewal, and should generally be removed at night; it is, therefore, well to teach the patient the method of application. After a little instruction, the task will be found very simple; the patients soon find out the best position for the pellet and the exact amount of pressure which renders it effective. During the introduction, the external meatus must be straightened by drawing the auricle outwards and backwards. The pellet is grasped by a pair of forceps, and pushed to the bottom of the meatus with an inclination slightly forwards.

As a general rule, it is necessary that the parts should become gradually accustomed to the presence of any artificial substitute for the tympanic membrane. More or less irritation may be caused not only to the remains of the membrane and the tympanum, but to the structures of the labyrinth, and this result must be as far as possible avoided. For this purpose, the pellet should at first be worn only for an hour or two and then removed; and this practice must be pursued for several days, increasing the time until the pellet can be worn during the whole day. The pellet should be removed on the appearance of any sign of irritation. In some cases, the best plan is to let the patient wear it only when conversation becomes necessary.

With regard to the *modus operandi* of these appliances, Toynbee thought that the resonance of the tympanic cavity was restored by the rubber disk; but, against this view, it must be remembered that the perforation is not always closed by the disk, and certainly not occluded by a cotton-wool pellet, the effect of which is often considerable. Erhard considered that the effect was due to the pressure upon the remains of the membrane and the handle of the malleus, or upon the stapes if separated from the incus. His idea was that the bones, whose articulations had been loosened, were thus held closely together, with improvement of sound-conduction as the result. Alteration in the intra-labyrinthine pressure has also been suggested as an explanation. According to another view, pressure upon the short process of the malleus acts upon the ossicular chain, which, previously drawn inwards, is restored to a more natural position. In all probability these causes frequently co-operate, their influence varying in degree in different cases.

The employment of an artificial membrane is indicated when the perforation is accompanied by marked deafness on both sides, and when the inflammatory swelling of the remains of the membrane and of the mucous lining of the cavity and the suppuration have been reduced to a minimum. The appliance sometimes proves beneficial in cases in which the membrane is intact; the deafness, which is the prominent symptom, is momentarily improved by pressure upon the short process. When perforation exists only on one side, and the hearing-function is good on the other, an artificial membrane may be worn as a protection against the ingress of foreign bodies, though its good effects may be outweighed by the irritation it causes. The size of the perforation does not influence the results of the appliance, which, however, often acts remarkably well when the opening is large and the stapes exposed and freely movable.

The question whether the artificial appliance will prove useful in any given case, even if the external conditions appear favourable, can be determined only by repeated experiments. These should be conducted in the following manner: any exudation should be removed either by means of cotton-wool or by syringing. When the parts have been thoroughly dried, the hearing-power for speech should be tested. The artificial membrane is then introduced as previously directed, and the test is again applied. If the rubber disk be used, it should be of such a size and form as to overlap the margin of the opening; and before introduction it should be moistened with warm water, glycerine, or some antiseptic solution.

In some cases, the introduction of the appliance is followed by no alteration of hearing-power, but by pain and noises in the ear. Under such circumstances, it is well to alter the position of the artificial membrane or to try other appliances, until a different result is obtained. It sometimes happens that the patient is able, after a little instruction, to adjust the appliance and to make it act satisfactorily. When this result has been achieved, the improvement in the hearing-power is often very considerable; *e.g.*, a patient who previously could hear spoken words perhaps at no greater distance than 15 or 20 inches, can now hear a whisper uttered 6—10 yards off. Such an improvement is, however, impossible, if the ossicles, and especially the stapes, have been rendered all but immovable by adhesions. Apparent improvement in bone-conduction sometimes results from the use of one of these appliances.

After having tried several forms of artificial membrane, that one which causes the most improvement should be selected for use. If there still be any discharge from the ear, a pellet of cotton-wool, which can be impregnated with some antiseptic fluid, will be found the most suitable appliance. In all cases, should any signs of inflammation appear, the appliance must be disused for a few days, during which boric acid should be employed by insufflation. In some cases the application of an artificial tympanic membrane, though not materially improving the hearing-power, decidedly alleviates the subjective sensations, and is a source of great comfort to the patient.*

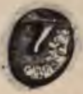


FIG. 112.

THE RIGHT TYMPANIC MEMBRANE of a man, aged 21 years, the subject of chronic middle-ear catarrh, with a large patch of calcareous deposit in the anterior and lower part of the membrane.

(3) **Calcareous Deposits in the Tympanic Membrane.**—Calcareous deposits are frequent results of various affections of the tympanic membrane, *e.g.*, of inflammation, with or without the formation of abscesses, of middle-ear catarrh, and of chronic purulent inflammation. When resulting from this last complaint, they are usually associated with cicatrices or persistent perforations (Figs. 105, 112). Their presence indicates previous infiltration, the result of inflammatory processes. The deposited matters have not been absorbed, but have undergone calcareous metamorphosis, in which amorphous calcium phosphate has been formed with more or less pigment. In some deposits the calcium phosphate takes the form of crystals.

---

* This is in harmony with the experience of Dr. Gompertz, and others. See discussion recorded in ***Journal of Laryngology, Rhinology, and Otology***, April, 1895, p. 324.

These calcareous deposits occur as patches varying in size, either isolated or collected together, so as to form more or less crescentic masses in the substance of the tympanic membrane; they are greyish-white, like chalk, or perhaps somewhat yellowish in colour. The margin towards the periphery is usually smooth, whereas the concavity, towards the umbo, is often irregularly serrate or dentate. When thick they cause the internal surface of the membrane to become uneven, as if some fluid plaster had been poured over it and had set irregularly. If, on the other hand, the calcareous masses are nearer the external surface, they form little elevations thereon, like those on a map in relief. Between the calcareous portions and the handle of the malleus, and likewise between the former and the circumference, the membrane is generally normal in character, and capable of executing vibrations. It very rarely happens that the entire structure is infiltrated, stiffened, and unyielding, as a result of calcareous deposit. Sometimes small calcareous patches are found scattered about in cicatrices; they are probably developed from infiltration resulting from recurrence of inflammation in the part. In very rare instances osseous deposits are found in the membrane.

Once formed, these calcareous deposits remain permanent; if inflammation of the membrane takes place, and the external layer becomes relaxed and injected, the patches appear larger, yellowish-red in colour, and more deeply imbedded in the surrounding parts. After the process has subsided, the deposits resume their former appearance.

There are no special subjective symptoms connected with these calcareous patches on the tympanic membrane. The deafness and noises in the ears, not infrequently present, are probably due to changes in the deeper parts. When, however, the greater portion of the membrane is occupied by calcareous deposits, its elasticity and capacity for vibration will be much impaired, with diminution of hearing-power as a direct result.

It seldom happens that any treatment is required for calcareous deposits in the tympanic membrane. The removal of such patches may cause inflammation, and can only be followed by cicatricial formation, by which the hearing-power will be still more impaired. Operative interference is, however, justifiable when the entire membrane is affected by the deposit, provided that the stapes be movable, and bone-conduction be little, if at all, impaired. Under such circumstances, improvement may be effected by excising the tympanic membrane and the malleus. Medical treatment, whether local or general, has no effect on such deposits.

Thickening of the Tympanic Membrane.—This condition, which is by no means infrequent, is distinguished from calcareous deposit by the fact that the diseased portions are not so clearly circumscribed, and are less white in tint. The thickening is due to increased volume of tissue, either epithelial or connective, or to deposit of molecular detritus; it may affect any layer of the membrane, or all of them to the same extent; it is apt to be most marked in the membrana propria, and it may be either diffused or limited to certain spots or zones.

The thickening more or less modifies the transparency of the membrane, and causes it to become cloudy; the affected spots have a whitish, milky, or tendinous appearance. This change sometimes causes a whitish semi-circle to be distinguishable; it begins at the short process, and passes downwards and backwards, and thence into the anterior inferior quadrant. In other cases, it forms a complete circle. In old persons, the lower half of the membrane is sometimes thus marked.

Opacity of the tympanic membrane is not infrequently caused by new formations of connective tissue within the cavity. These take the form of bands or false membranes, extending from the tympanic walls or ossicles to the internal surface of the membrana tympani; and the opacities they cause vary in size according to their form and the extent of surface to which they are attached. In all such conditions, the lustre of the membrane and the reflection of light may remain unchanged; it is only when the epidermis of the cutis is insufficiently illuminated (as in young children) or much increased (as in old persons) that the external surface of the membrane has a dull, lustreless appearance.

Permanent opacities of the tympanic membrane have to be distinguished from similar appearances due to the presence of morbid products within the cavity, such as accompany the various catarrhal and inflammatory affections already described. The history of the case, and the fact that the opacity is confined to or most marked in the lower part of the tympanic membrane, and undergoes various alterations when the tympanum is inflated, will serve to distinguish the two conditions.

It remains to add a few words on an opposite condition of the membrana tympani, viz., loss of substance, which sometimes occurs in patches, either alone, or while thickenings exist in other portions of the membrane. The change principally affects the membrana propria, the fibres of which, once destroyed, are not renewed. The nutritive disorder which produces this result may be of a subacute inflammatory character, with infiltration as a consequence; or it may be attendant upon abnormal conditions of pressure and tension, the effects upon the membrane being the degeneration of its fibres, molecular disintegration, fatty changes, and absorption. Atrophy is the ultimate result, and the affected portions of the membrane are therefore thinner and less resistant. If the wasting process be of a more rapid character, and attended with exudation into the tissue of the membrane and softening, the process is apt to involve all the layers, and perforation is the necessary consequence.

In atrophic processes, such as those just described, only small islets of the membrane may be affected, or the greater portion thereof may be involved, and between the two extremes there are many intermediate degrees. The atrophied portions are more transparent, have a darker look, and are below the level of the adjacent parts. They are darker, because when light impinges upon them only a smaller portion is reflected, the greater part being transmitted. The inner wall of the tympanum is not, however, a good reflecting surface, and therefore less light reaches the eye; this diminished reflection causes the atrophied spots to appear darker, as compared with the parts immediately surrounding them. The alteration in the level of the affected spots and their depressed position are due to the absence of the membrana propria. Hence they offer less resistance to the pressure of the atmosphere and become concave. Such circumscribed, dark, and depressed spots may be mistaken for perforations. A similar mistake may also be made when the whole membrane is in a marked state of atrophy, so that the inner wall of the tympanum becomes clearly visible.

The movements of these atrophied spots during the respiratory acts and under the influence of the air-douche are the

th
ai
ef
M
is
dep
cic
to
to
me
most
diffi
T
the
spots
chang
able;
backwa
other
half of
Opa
by new
take the
tympanic
tympani;
their form
In all
reflection
the epide
young chi
the externa
appearance.
Perman
be distingui
of morbid p
various catar
The history
confined to or

laxed cicatrices under

Membrane and the ...panum.—These are a frequent the remains of the n, or the cicatrix itself contents of the cavity. place between the central promontory, or between the ing process of the incus. adherent; but in excep- part of the membrane between the incus and generally formed during When they are complete. altogether; but suppuration of the tympanum, and conse

rane and the inner wall of the of the incus, are for the most the air-douche is used, or the means of Siegle's speculum, the still more depressed. Before the mbrane, as seen from the meatus, the handle of the malleus is and drawn more or less forwards Sometimes it lies horizontally avity. When the membrane is the attached portion appears as a margin. The attachment may of connective tissue; in the latter arked, and the spot is opaque and in colour. Adhesion between the and the membrane appears as a when the malleus is connected by emity of the incus, a patch of the recognised.

described alter considerably after air tympanum. If the adhesion be suffi- resist the force of the air, no change will be noticed in the appearance of the spot itself, but the membrane at the circumference will be forced more or less outwards, and will reflect the light differently. If the result of the injection be to separate the membrane from its attachment and to break up adhesions, the abnormal concavity will to a great extent disappear, and a reddish tint may be noticeable, due to escape of blood from ruptured vessels.

Politzer recommends that a probe should be used to assist in the diagnosis of adhesions. If any portions of the membrane fail to move when air is injected or when Siegle's speculum is used, and a firm osseous basis can be felt with the probe, it may be inferred that the cicatrix is directly connected with the bony wall. It must, however, be remembered that thickened and calcified portions of the membrane will appear, when touched, as hard as bone.

The manner in which light is reflected also serves to guide the diagnosis. When the lower portion of the membrane is adherent to the inner wall of the tympanum, the normal cone of light is decidedly enlarged. When the posterior segment of the membrane is adherent, the light is reflected from a triangular spot, the apex of which corresponds with the extremity of the handle of the malleus, while the base is towards the promontory. If this cone of light remain unaltered when the membrane is forced outwards by the air-douche, there can be no doubt as to the existence of adhesions.

When the membrane is attached by connective tissue to the inner wall, and is, therefore, somewhat movable, the diagnosis becomes more difficult. Inflation of the tympanum may, in such a case, cause the membrane to bulge outwards and produce a decided change in the reflection of the light; but, unless the movement be somewhat considerable, there will be no marked depression corresponding with the adherent spot. Appearances similar to those caused by adhesions may also be due to increased tension of portions of the membrane. When air is forced into the tympanum, such portions, being more resistant to pressure, remain below the surface of the membrane generally, as is the case with adhesions. When this condition is noticed and the depressed spot is at the same time opaque, the question whether adhesions exist will be very difficult to determine.

The adhesions which are formed between various portions of the tympanum are liable to produce great alterations in the condition of the cavity. The latter is often divided into irregular spaces, either communicating with or shut off from each other; and the opening into the Eustachian tube and into the mastoid antrum may be completely occluded by false membrane. Spaces of this kind, formed in the tympanum and shut off from the air, become filled with epithelial débris and particles of cholesterin. As a matter of course, the size of the cavity is much reduced by the connective-tissue formations, which not only extend across it, but sometimes fill up the depressions so as completely to obliterate them. As a further result, the bands and layers of connective tissue sometimes become ossified or indurated from calcareous deposits, and produce ankylosis of the ossicles and rigidity of the fenestra rotunda, with serious impairment of hearing-power as a necessary result.

In these cases of adherent cicatrices of the membrana tympani, the degree in which the hearing-power is affected varies with the condition of the ossicles and fenestræ. The impairment is least in those cases in which only that part of the membrane which is below the handle of the malleus is adherent to the inner wall. When, however, the upper portion is affected and the handle of the malleus is drawn inwards and united with the promontory, and the incus and stapes are adherent to the membrane, the obstacles to the conduction of sound will necessarily be very great. Some compensation occurs in those cases in which the stapes, though separated from the incus, becomes adherent to the membrane; sound is then conducted from the latter to the bone in contact with it.

Treatment of Adhesions.—When the hearing-power is decidedly impaired, and no improvement results from inflation, from the use of Siegle's pneumatic speculum, and other methods already described, division of the adherent tissues may prove successful. Obstinate subjective sensations are also sometimes relieved by operations of this kind, which are, however, contra-indicated when bone-conduction is lost or considerably diminished.

The indications for operative treatment are by no means clearly defined; they are summed up as follows by Politzer, who has operated repeatedly with a fair amount of success:—

(1) When adhesions exist between the membrana tympani

and the inner wall; when the surface of the former is marked by irregular depressions and bar-like ridges, while the ossicles are immovable and the hearing-power is much impaired. The condition of the membrane remains unchanged when the air is rarefied in the meatus. Under such circumstances, the operation consists in dividing the ridges at right angles to their course; one or two incisions are made with a small knife rounded off at its extremity, and are carried down to the promontory. Politzer states that he obtained favourable results in cases in which band-like ridges extended between the handle of the malleus and the articulation between the incus and stapes. The edges of the incisions are apt to unite soon after the operation, the result of which is sometimes permanent, but sometimes temporary.

(2) When the lower end of the handle of the malleus is united with the wall of the promontory, so that the incus and stapes are drawn inwards, there is serious impairment of hearing, which may, however, be relieved by several incisions, made at right angles, into the cicatricial tissue, near the extremity of the handle of the malleus. The operation will prove useless, if the latter bone and the incus be imbedded in connective tissue. If, in such cases, the articulation between the stapes and incus be exposed, and the condition be improved when pressure is made with a probe, the inference may be drawn that the adherence of the malleus to the promontory keeps the remaining ossicles in a tense condition. To remedy this, and to release the stapes, Politzer divides the long process of the incus by means of a pair of small scissors, having blades 4mm. long and 1½mm. wide. One blade is fixed, while the other moves with a lever action. The scissors, fitted into an appropriately curved handle, with the blades closed, are passed in a horizontal direction towards the long process of the incus, and then opened, pushed forward, and closed. After the operation, in order to prevent union, a probe is used to push the upper end of the bone backwards and upwards; some amount of force is necessary for this purpose. The position of the bone cannot be altered when there is much connective tissue in the upper tympanic spaces, or when there is ankylosis of the incus.

(3) When the movements of the stapes are interfered with by fibrous connective tissue in the posterior superior portion of the

promontory, and in the pelvis ovalis. In these cases, a horizontal incision is carried below the head of the stapes, dividing the cicatricial tissue and releasing the bone to some extent. If little or no improvement result, another incision should be made, parallel to the former, but above the head of the stapes. If the tendon of the stapedius muscle be imbedded in the cicatricial tissue in the niche of the fenestra ovalis, and is visible on the surface of the cicatrix as a whitish band, extending backwards from the head of the stapes, an incision through the new tissue will include the tendon, and should be carried at right angles to its course. Other methods are required for cases in which no opening exists in the tympanic membrane; but its tissue is so changed as to allow bands of false membrane to be visible through it, and no alteration is produced either by the air-douche or by aspiration. If an operation be decided upon, the first step is to make an opening in the membrane with a paracentesis needle close to the spot, where the band appears to be attached. A tenotome, suitably curved near its apex, is passed through this opening, and the band is then divided. Wreden's instrument consists of a lancet-headed needle, bent close to its apex nearly to a right angle, and having a very sharp edge all round. The needle is attached to a handle, and can be fixed in any position by means of a screw-arrangement.

Separation is usually attended with great difficulties when portions of the membrane are closely applied to the inner wall and firmly adherent. The method of operating is to make an incision just outside the margin of the adherent spot, and then to introduce a curved needle terminating in a flattened extremity, resembling a very small sharp spoon. An American surgeon, Dr. Prout,* divides adhesions between the membrane and the promontory with a very small iridectomy knife, having a long handle. He allows the adherent portion to remain, and thus establishes a permanent opening in the membrane. In a case thus treated, hearing-power for the voice was much improved by the operation. "A year afterwards the opening in the membrane remained of the original size; the cavity of the tympanum was dry; the watch was heard when pressed upon the auricle—before the operation it was not heard at all; and ordinary conversation was readily heard at the distance of twenty feet." Chronic suppurative inflammation was the result in another case.

---

* Roosa's *Treatise on Diseases of the Ear*, p. 433.

Schwartze* maintains that in the large majority of cases, the operations above referred to have proved unsuccessful. Antiseptic precautions render them almost, if not altogether, free from danger; but the improved hearing-power obtained in the most favourable cases is, for the most part, transient. Adhesion again takes place, and the deafness and subjective sensations exhibit no change. The best results are witnessed after the division of tight cord-like bands, whose insertion into the membrane or handle of the malleus is distinctly visible through the former structure. Adhesions between the promontory and the malleus are especially suitable for operation. Should reunion take place, complete excision of the malleus is the only method of treatment likely to prove successful.

The author considers that these operations should not be undertaken except under special circumstances, because permanent improvement in hearing, as a result, is doubtful, and there is a risk of increasing the deafness already present.

---

* *Handbuch der Ohrenheilkunde*, Bd. II. S. 766.

CHAPTER XXX.

CONSEQUENCES AND SEQUELÆ OF CHRONIC MIDDLE-EAR SUPPURATION.

Formation of Cholesteatomatous Masses in the Tympanic Cavities—The Growth of Polypi—Caries and Necrosis of the Temporal Bone—Extension of Inflammation to the Mastoid Process and Cells—Cholesteatoma of the Tympanum, Nature and Pathology—Theories Advanced by Tröltsch, Habermann, and Politzer—Symptoms and Consequences—Diagnosis—Prognosis—Treatment.

In the account, given in a previous chapter, of chronic middle-ear suppuration, reference was made to the fact that the disease is very prone to lead to further consequences and changes, some of which affect particularly the structures of the organ of hearing, while others involve various parts more or less closely connected therewith. In this and in three succeeding chapters, a description will be given of those consequences which may be included in the first category; in subsequent pages, those which belong to the second will be duly considered.

The principal consequences and sequelæ which implicate the organ of hearing are four in number, and will be described in the following order: (1) The formation of cholesteatomatous masses in the tympanic cavities. (2) The growth of polypi. (3) Caries and necrosis of the osseous walls of the ear and other parts of the temporal bone. (4) Extension of inflammation to the mastoid process and cells.

CHOLESTEATOMA OF THE EAR.

This term has been somewhat generally applied to various morbid conditions of the organ of hearing. About sixty years ago it was used by J. Müller to designate certain new formations in the temporal bone, resembling the pearly growths sometimes found in the pia mater at the base of the brain. They constitute hard, dry and rounded masses, made up of concentric layers of epidermoid cells, with crystals of cholesterin between them. The growths are enveloped in a delicate membrane, closely adherent to the periosteum of the cavity in which they are developed. They are most often found in the upper and most external portions of the middle ear (the attic and the mastoid antrum). A growth of this kind is at first inclosed in the bone; and it may not extend beyond the walls of the cavity in which it has originated. More frequently, however, it gradually increases in size, dilates the osseous cavity, and finally perforates the bone. Thus an opening may be formed into the external meatus, the tympanum, the cranial cavity, or upon the surface of the mastoid process. The destruction of the bone may be very gradual and unattended by any marked symptoms; in other cases, however, there is more or less inflammation of the adjacent tissues, accompanied by suppuration, caries, or necrosis. Should the inflammatory process extend towards the tympanum or the external meatus, perforation of the membrane, or openings in the posterior superior osseous wall are likely to ensue. In either case there will be more or less discharge from the meatus. Extension in other directions, *e.g.*, to the sigmoid sinus or to the dura mater, may cause thrombosis or meningitis respectively.

This form of cholesteatoma is described as "primary"; it is not preceded by inflammatory changes in the middle ear or adjacent cavities. It is regarded as heteroplastic, inasmuch as it becomes developed in portions of the organ of hearing, which, in their normal state, do not contain epidermoid tissues. Opinions differ as to its source of origin. According to one theory, it is formed from the epithelium of the ductus vestibuli; while other authorities suggest that, in the closure of the second visceral cleft, some epidermic cells are abnormally retained and remain in the tympanic cavities. These cells are the basis whence cholesteatomata may originate; and their development is likely to be favoured by inflammatory processes in the middle ear.

The occurrence of this primary form of cholesteatoma has been regarded as quite exceptional, or, indeed, very doubtful; but cases have been recorded by good observers, in which such growths existed in the absence of any lesion of the tympanic membrane, and without any trace of inflammatory processes within the tympanum. Their existence was manifested by giddiness, headache, and cerebral symptoms, and the sudden appearance of a growth in the external meatus or upon the surface of the mastoid process. The size of the growth clearly indicated its long duration. In a case recorded by Urbantschitsch,* the posterior superior quadrant of an imperforate tympanic membrane was forced outwards by an intratympanic growth. An incision was made, and the posterior and upper part of the tympanic cavity was found to be occupied by a mass of cholesteatoma, which was removed with a curette. A feeling of pressure in the ear had led the patient to seek advice; there was no history of any previous aural disease. Lucae also refers to a case in which the tympanum contained a cholesteatoma, the membrane being imperforate.

An entirely different view of the origin of these masses has been put forth by v. Tröltsch† and others. They are to be regarded as epithelial and purulent accumulations, produced by chronic inflammatory changes in the mucous membrane of the middle ear, and retained in the cavities. They are therefore secondary formations. The centre of such a mass is always formed by a nucleus of desiccated pus, which by the pressure gradually exercised on certain parts of the middle ear, and especially on the walls of the antrum, causes the formation of large quantities of cellular products, so modified as to resemble stratified epithelium, packed in shining masses. As a matter of fact, however, a central nucleus is often indistinguishable; and this theory fails to explain the existence of the epidermoid capsule, which lines the cavities containing the new growths. Moveover, it does not account for those cases in which the tympanic membrane remains unchanged. According to another theory, these growths are the result of proliferation of the epidermis of the granulations in purulent middle-ear inflammation. The oldest layers become detached and accumulate in the tympanic spaces.

---

* *Lehrbuch der Ohrenheilkunde*, Aufl. III. S. 288.

† *Arch. f. Ohrenheilkunde*, Bd. IV. S. 97.

According to Prof. Habermann,* whose views have been adopted by Politzer, the formation of cholesteatoma is due to the growth and development of the epidermis of the external meatus or of the membrana tympani, and the occupation by such growth of the spaces of the middle ear. During chronic inflammation of the lining membrane of the tympanum, there is active proliferation of the epidermis of the membrana tympani and of the adjacent portion of the meatus. This process not infrequently extends over the margin of a perforation to the ulcerated mucous membrane of the middle ear, and thus not only the tympanum, but the mastoid antrum becomes coated with epidermis, and then, if the inflammation cease, healing takes place. If, however, the process continue, and be accompanied by more active proliferation of the cells of the Malpighian layer, these latter will enormously increase, and the horny layers will become detached. Should these not escape through the meatus, the cells (accumulating in layers for the most part concentric) will form masses corresponding in size and shape to the spaces they occupy, and such masses constitute a cholesteatoma.

According to this view, a cholesteatoma represents a sac-like growth of the epidermis of the membrane or of the meatus into the middle ear; and from a mass of this kind, similar prolongations may branch off and occupy spaces near at hand. Habermann † gives a drawing of a cholesteatoma of the mastoid antrum, formed by the growth of epidermis in the vicinity of Shrapnell's membrane. From the primary formation, a branch extended and filled the space between the malleus and the incus on the one side, and the inner wall of the cavity on the other. These lateral prolongations are probably due to the development of plug-shaped portions from the Malpighian layer, which then become hardened in their centres—a process similar to that which sometimes occurs in polypoid growths. The so-called "epithelial pearls," sometimes formed on the membrana tympani, and on cicatrices after perforation, have a similar origin.

---

* *Arch. f. Ohrenheilkunde*, Bd. xxvii. S. 42.

† Dr. H. Schwartze's *Handbuch der Ohrenheilkunde*, Bd. I. S. 257.

These "secondary" formations are much more common than those of primary origin. Long ago the fact was recognised that otorrhœa is sometimes spontaneously cured by a prolongation into the tympanum of the integument of the meatus, which by degrees forms a coating over the cavities of the middle ear.*

Symptoms and Consequences.—The presence of these masses in the cavities of the middle ear may be attended with very serious results. Owing to their peculiar structure, they are especially liable to be acted upon and increased in size by the infiltration of fluid matters; and they are, moreover, constantly growing by additions from without. They may attain the size of an ordinary walnut. At first the growth is entirely inclosed within the bone, and it may continue to be thus limited; but the slight and continuous pressure on the walls of the cavities tends to cause atrophy and even loss of substance and the formation of gaps. Openings may thus be formed into the large vascular channels, and into the cavity of the skull. When the mastoid antrum and cells are occupied by cholesteatoma, openings may form in the posterior wall of the meatus, or on the surface of the mastoid process, or prolongation of the growth may take place into the attic, and thence through Shrapnell's membrane. In some cases, the masses undergo decomposition, with pyæmia or suppuration within the cranium as results. Micro-organisms are invariably present, and all the conditions are favourable to their growth and development. The formation of cholesteatoma is most often observed in tuberculous subjects, who are especially prone to suffer from chronic suppurative disorders of the middle ear.

Cholesteatomatous formations may continue for some time in a quiescent state, without causing any very marked symptoms. Sooner or later, however, they will produce more or less deafness, tinnitus, and discomfort or pain in the ear. Febrile symptoms, due to retention of purulent discharge, giddiness and vomiting are not infrequently superadded. The severity of the symptoms is increased from time to time, owing doubtless to swelling of the masses. This result is sometimes witnessed after syringing the ear.

---

* J. C. Saunders, *The Anatomy of the Human Ear*, etc., London, 1829.

Diagnosis.—The nature of the case can be positively determined only when cholesteatomatous masses are visible in the meatus or tympanum, or when fragments of the same are removed by syringing. Characteristic portions can occasionally be detached with a probe or scoop. It sometimes happens in these cases that the examination is rendered very difficult by swelling of the posterior and upper wall of the meatus, to such a degree as to occlude a large portion of the canal. A good light and the greatest care are necessary during the examination. When the growth occupies the mastoid antrum and cells, there are often signs of inflammatory irritation and swelling of the adjacent parts.

The **Prognosis** is always more or less grave, by reason of the danger that exists of the growth's breaking through the bony walls and setting up mischief in important structures. The formation of cholesteatoma may go on for some time without causing any decided symptoms. Retention of purulent matters is indicated by pain in the head, great tenderness of the parts about the ear, rigors, giddiness, fever, and vomiting. As already stated, openings may form in various directions, *e.g.*, into the external meatus, through the posterior wall; externally, through the mastoid portion; into the labyrinth, the lateral sinus, or into the middle or posterior fossa. Of these possibilities, an external opening is the only favourable course. Pyæmia, meningitis, or cerebral abscess may be set up in the event of implication of other portions of the temporal bone. The prognosis is decidedly influenced by the degree of facility with which the removal of fragments and disinfection of the cavity can be effected. So long as any portion remains there is danger of infection, which is reinforced by the tendency to fresh formations.

Treatment.—This consists in the removal of the mass and the application of antiseptic and other remedies to the cavities it occupied. When the tympanic membrane has been completely destroyed, it may be possible to remove the entire growth with the aid of a blunt hook. Fragments and detached portions are difficult to deal with, but sometimes they can be drawn out by means of forceps. If they cannot be reached from the meatus, careful syringing or irrigation should be practised, with the aid, if necessary, of the tympanic irrigator (Fig. 99, page 446). After these attempts the parts should be thoroughly dried, and subsequently dusted over with iodol. Any existing granulations or polypoid growths should be carefully removed or otherwise treated. So long as these remain, reaccumulation is certain to take place. If the opening in the membrane be so small as to prevent the escape of débris, it should be carefully enlarged with the paracentesis knife. If an opening has formed in the wall of the meatus or of the mastoid process, removal of the mass in some cases may be thence effected. Excision of the malleus and incus, both of which are often more or less carious, followed by thorough cleansing and repeated insufflations of boric acid, may suffice for the cure of some cases of cholesteatoma. Bezold* considers that an etiological relation probably exists between catarrh of the tubes, perforation of Shrapnell's membrane, and cholesteatomatous formations. The development of these latter may therefore be prevented by the adoption of Politzer's method of inflating the middle ear, and by the removal of adenoid growths from the naso-pharynx.

There is another way of acting upon these accumulated masses, viz., by injecting fluids through the Eustachian tube into the tympanum, and this plan is especially useful in cases in which any obstructions exist in the meatus. Rapid injection is to be avoided, inasmuch as it is liable to cause giddiness, pain, and various other symptoms. When carefully performed, great quantities of accumulations can sometimes thus be removed from the tympanum, and the immediate results of their removal are often very satisfactory. After thorough cleansing and drying the ear, it is well to instil a few drops of alcohol from time to time, as little diluted as can be borne, with the view of checking epithelial desquamation. Such patients should, however, be frequently seen by the surgeon, so that proper steps may be taken to prevent recurrence of accumulations.

These measures, designed for the removal of a cholesteatomatous mass from the tympanum, or from superficial cavities, are often insufficient in consequence of the inability to get away the whole of the mass, and of the mastoid antrum's being involved. Frequently also the attic contains granulations which cannot be thoroughly removed through the meatus. Should the attempts which have been thus made to effect a cure prove ineffectual, the mastoid antrum and the attic must be opened in the manner which will be hereafter described. This operation must also be at once undertaken should head-symptoms supervene, or when there are signs of inflammation in the mastoid region, and when there is persistent and fœtid otorrhœa.

---

* "Treatment of Cholesteatoma of the Middle Ear," *Archives of Otology*, vol. xx. p. 305.

CHAPTER XXXI.

POLYPI OF THE EAR.

Classification of Polypoid Growths—Mucous Polypi or Granulation Tumours—Fibrous Polypi—Angio-Fibromata—Myxomata—Relative Frequency of Various Forms—Etiology—Chronic Middle-Ear Suppuration—Sex and Age—Seat of Origin—Number of Polypi—The Pedicle—Size and General Conformation of Aural Polypi—Symptoms, Subjective and Objective—Consequences which may Result—Development and Progress of the Growths—Diagnosis—Polypi of the Tympanum, with the Membrane Intact—Treatment—Operative and by Application of Remedies—Removal by the Snare—Politzer's Knife—The Use of Scoops and Crushing Forceps—The Galvano-Cautery—Caustic and Astringent Applications—Acids—Alcohol, Cases for which Adapted—Acetate of Lead.

POLYPI and polypoid growths are frequently found in the tympanic cavity and external meatus. The great majority originate in the tympanum. In a small proportion of cases, the tympanic membrane, the mastoid cells, and the walls of the Eustachian tubes are the seat of the growths. Considered with regard to their structure, these growths may be divided into three, or perhaps four, classes, and designated as *mucous polypi*, also termed round-celled polypi or granulation tumours, *fibromata*, and *myxomata*. Some of the fibromatous growths are extremely vascular, and hence have been named *angio-fibromata*.

The **Mucous Polypi** or **Granulation Tumours** are those which most often occur. They consist of a delicate fundamental tissue, between the fibrils of which are imbedded many cells, mostly round, but some oval and spindle-shaped (Fig. 113). These growths are freely supplied with vessels, and they sometimes contain cysts and gland-like formations. The depressions and fissures on the surface are due to the inward proliferation and disintegration of epithelial cells; and to the same cause may be attributed some of the gland-like formations which often extend more or less deeply into the growths. In other instances these formations are due to hyperplasia of glands normally occurring in the meatus; the mucous membrane of the tympanum does not contain glands. The small cysts, also common, are the result of retention of glandular secretion. In rare cases the polypus is made up of a single cyst containing fluid.

The surface of the polypi is often stained with blood owing to their vascularity and the size of their capillary vessels. These form loops under the surface; the largest vessels are to be found in the stalk of the polypus, whence they give off many branches.

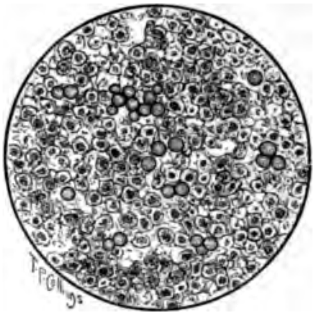


FIG. 113.

GRANULATION POLYPUS. x 200.

The **Fibrous Polypi,** which usually grow from the periosteum, are firm and resistant to pressure; on section they are paler and less vascular than those just described. According to Moos and Steinbrügge,* blood-vessels are only indirectly connected with the development of the fibromata, whereas they take a direct part in that of the angio-fibromata. Formative cells which have wandered from the blood-vessels are the source of fibromata; these give rise to spindle-cells, and these again to connective tissue fibres, which predominate in the stroma of the tumour and give it its peculiar appearance (Figs. 114 and 115).

Angio-Fibromata begin as granulation tumours, and are the result of proliferation of the elements of the vascular walls.

---

* *Archives of Otology*, vol. xi. No. 4.

The cells of the *tunica adventitia* also proliferate, and thus produce a network of cellular strands. The same process takes place in

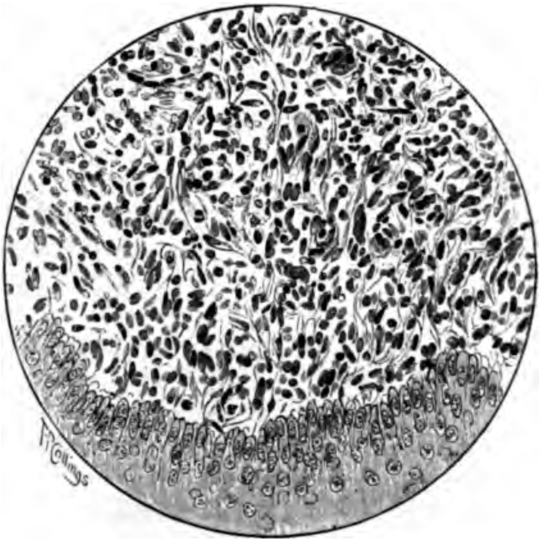


FIG. 114.
EARLY STAGE OF FIBROUS POLYPUS. × 300.
(From a Patient, aged 20.)

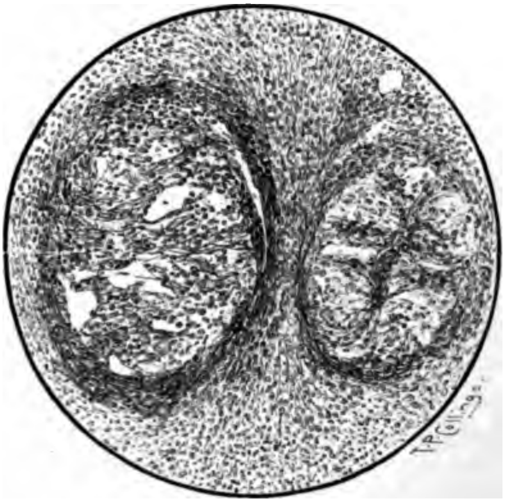


FIG. 115.
LATER STAGE OF FIBROUS POLYPUS, SHOWING TWO PATCHES OF TISSUE UNDERGOING MUCOID DEGENERATION. × 100.
(From a Patient, aged 30.)

the endothelium, and the vascular walls increase in thickness, sometimes to such an extent that many of the vessels become obliterated. The elements of the cellular strands become transformed into spindle-shaped cells, and these again into connective tissue fibres (Fig. 116). The structure of such a tumour resembles that of a cylindroma, or angio-sarcoma, but the latter is distinguished by the facts that the neighbouring tissues are prone to be invaded, and that secondary growths are often seen.

Myxomata.—Aural polypi belonging to this class are very rare. They consist of gelatinous connective tissue, having its cells and fibrils separated and interpenetrated by a transparent fluid (Fig. 117). It is supposed that they are developed from some remains of those mucous tissues which had outlasted fœtal life.

With regard to the relative frequency of these four classes of polypi, Moos and Steinbrügge's tables show the following proportions:—

Granulation tumours	55
Angio-fibromata	27
Fibromata	14
Myxomata	4
	100

Aural polypi often present certain peculiarities of structure. Thus, small cholesteatomatous masses may be found in the centre of the growths, and likewise extravasations of blood, blood-corpuscles, and blood-pigment, with hæmin crystals. Minute bony formations are sometimes noticeable.

Etiology.—The formation of aural polypi is in many cases traceable to *chronic suppurative inflammation of the tympanum*, which is often associated with hypertrophy of connective tissue. They occur in about 11 per cent. of these cases. Purulent secretion acts as an irritant; its influence is shown by the fact that polypi in cases of suppuration diminish in size, and often disappear, as the latter subsides under treatment. In Moos and Steinbrügge's series of 100 cases, otorrhœa was absent in only one instance. Polypi are often associated with external indications of tuberculosis, and in such cases are prone to reappear after removal. *Local affections* in the ear, such as circumscribed

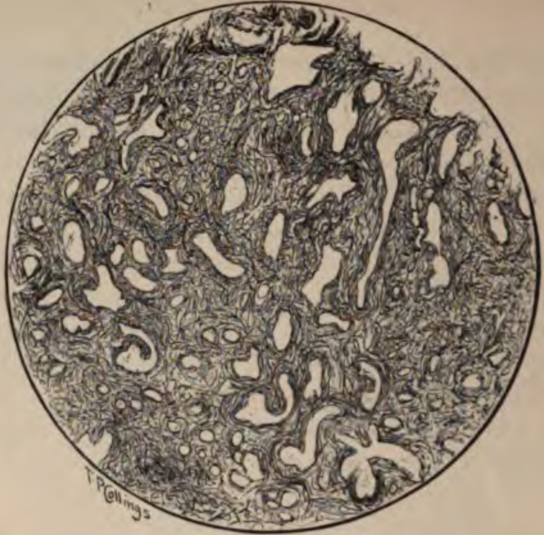


FIG. 116.

ANGIO-FIBROMATOUS POLYPUS. × 25.
(From a Patient, aged 20.)

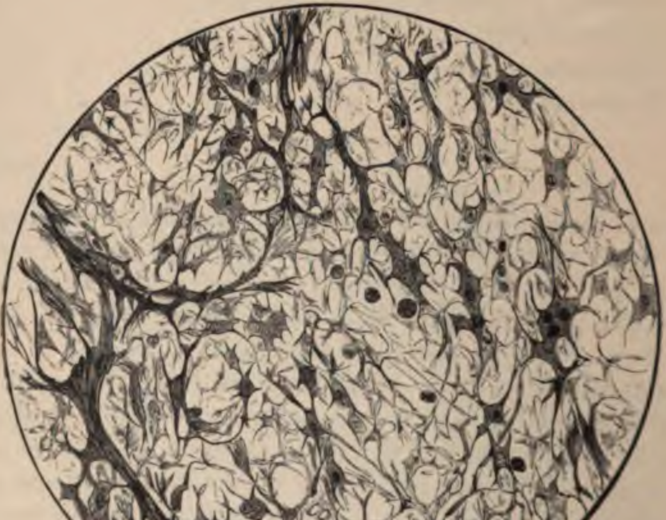


FIG. 117.

MYXOMATOUS, FIBRO-MYXOMATOUS, OR MUCOUS POLYPUS. × 300.
(From a Patient, aged 25.)

caries or *necrosis* of the walls of the tympanum, are apt to give rise to polypoid growths, which subside when the osseous disease is cured. Polypi of the meatus, besides being caused by local affections, are sometimes due to irritative processes in the middle ear, without perforation of the tympanum.

In some cases of aural polypi the etiology is obscure, and no history of suppuration or previous mischief can be obtained. It is probable that the real cause is often forgotten, owing to the interval that has elapsed between its occurrence and the manifestation of the growth, and to the inattention of the patient. In 10 per cent. of Moos and Steinbrügge's cases, the formation of aural polypi could be ascribed to scarlatina; and in 6, to other infectious diseases.

With regard to the *sex of the patients*, these polypi are more common in males than in females, perhaps because the former are more often exposed to sources of irritation. Out of 100 cases noticed by the above-named authors, there were sixty-six males and twenty-seven females, and seven not noted.

Aural polypi are *most frequent during the second decade of life.* The ages of the patients just referred to may be tabulated thus:—

Between 1 and 10 years	12 cases.
" 10 " 20 "	36 "
" 20 " 30 "	23 "
" 30 " 40 "	9 "
" 40 " 50 "	9 "
" 50 " 60 "	1 "
" 60 " 70 "	4 "
Unknown	6 "

A few cases of congenital aural polypus have been placed on record.

In the majority of cases (68 per cent.) aural polypi originate in the tympanic cavity, and from its internal and superior walls and the tissue covering the ossicles; in 25 per cent. the tumours are attached to the walls of the meatus. The pedicle is connected with the superficial layer either of the cutis or of the mucous membrane, or may be more deeply attached, and even to the bone itself. Polypi are sometimes, though rarely, connected with the membrana tympani, and they have been found on both sides of that structure. In cases of perforation of the membrane, minute polypoid growths are sometimes seen to spring from the margins of the aperture. The tympanic orifice of the Eustachian tube is the occasional seat of polypous formations.

Polypi are usually single, but multiple growths are found in about 19 per cent. of all cases. In those already alluded to, the multiple polypi occurred sometimes in the meatus alone, in a few cases in the tympanum alone, and six times in both places simultaneously.

The *pedicles* or *stalks* of aural polypi vary in length and thickness; in some cases the growths are sessile, and consist of minute lobules attached to a common base. The pedicle is sometimes branched, each branch supporting a head, and it may contain one or more cavities resembling cysts. Nerve-filaments are found in the pedicles, but not in the heads of the polypi. Sometimes a polypus is attached to its base by several roots, and it not infrequently happens that a growth becomes attached at various points to the surrounding parts, and thus additional pedicles are formed. Small excrescences not infrequently surround the point to which the root is fixed. In some cases polypi spring from the mastoid cells, and appear in the external meatus, after the posterior and superior walls of the canal have been destroyed.

Aural polypi vary considerably in *size;* sometimes they are very minute, and only just perceptible; sometimes they fill up both tympanum and meatus, and protrude from the latter (see Fig. 118). In the majority of cases which come before the surgeon, the growths are as large as, or larger than, a pea. In some cases of suppurative inflammation of the tympanum, the growth of polypi is exceedingly rapid, and may be watched from day to day.

The *surface* of the granulation tumours or mucous polypi is generally much indented and lobulated, like that of a raspberry. In the case of large growths, the depressions are apt to be obliterated as a result of pressure, and the surface becomes smooth and glistening. In fibrous polypi, depressions are generally absent, and the surface is rounded and smooth. In most cases there is a Malpighian investing membrane, with its horny layer; the epithelium towards the root is either cylindrical or ciliated, but over the body of the polypus is generally tessellated and composed of several layers. The mechanical conditions of the growths have an important influence upon the amount and character of the epithelial covering.

Symptoms.—These may be classified as subjective and objective. With regard to subjective symptoms, they may be altogether absent in the case of small polypi, or masked by those of some previous affection. Otorrhœa is always present; and in cases of large polypi not a few serious symptoms may result from the obstacles thus opposed to the free escape of the discharge.

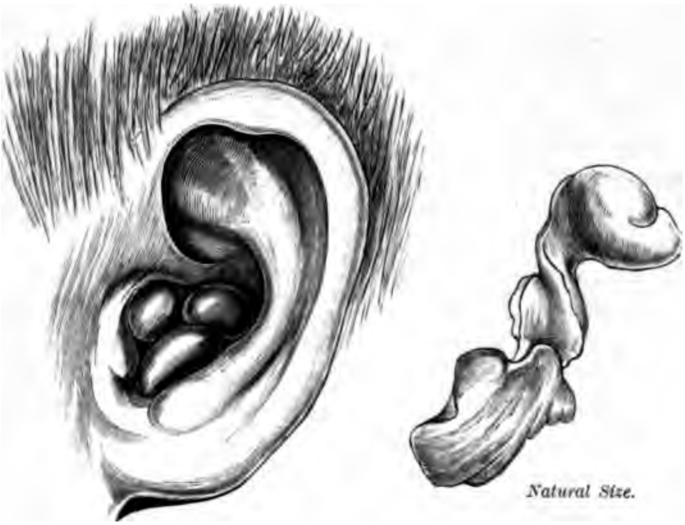


FIG. 118.

A FIBROUS POLYPUS removed by the author from a boy, aged 14 years. The triple appearance before removal was due to the lobulated shape of the outer extremity of the growth.

Besides deafness and subjective auditory sensations, the patients may complain of headache, vertigo, vomiting, supra-orbital neuralgia, and clonic spasms in the extremities of the affected side. Ptosis and hemianæsthesia have also been observed, and in a few cases epileptiform attacks accompanied the disorder in the ear. In all these instances the cerebral symptoms disappeared when the hindrance to the escape of pus was removed.

The **Objective Symptoms** depend upon the situation, progress, and size of the growth. Besides purulent discharge, hæmorrhage is almost always present; and when the polypus is a large one, a red growth, either smooth or more or less lobulated, may be seen to occupy the external meatus. In the large majority of cases, viz., in about 80 per cent., the membrana tympani is found to be either perforated or destroyed. This fact shows that the prime cause of the formation of polypi is to be sought for in suppurative inflammation of the tympanum; it also explains the extremely frequent origin of the tumour from the mucous membrane of the cavity, especially from the labyrinthine wall. In cases of polypi growing from the meatus, the membrana tympani is generally found to be intact, at least in the earlier stages.

The retention within the tympanum *of the products of suppuration* is the most serious cause of danger in connection with aural polypi. Such retention may cause caries and necrosis of the bone, and the irritation is very liable to extend to the membranes of the brain. Sometimes the purulent secretion becomes condensed into cheesy masses, the decomposition of which leads to necrosis and its results.

As a general rule, the *development* of aural polypi is a lengthy process; and when a certain size has been attained, the growth is apt to remain stationary. There are, however, many exceptions to this rule, and in some cases the meatus becomes blocked up in a few weeks. Spontaneous discharge is a not infrequent ending, and this process is most common in large polypi with long and thin pedicles, which are liable to be lacerated and torn through. Twisting of the pedicle may also cause detachment, inasmuch as the blood-vessels are liable to be occluded. Fatty degeneration of the pedicle has occasionally been noticed, and in some cases the part becomes so fragile as to give way during syringing. Disappearance of a polypus is sometimes due to ulceration and atrophy. The occurrence of cholesteatomatous masses has been already noticed; and chalky and osseous deposits are sometimes found. It must be remembered that polypi are occasionally connected with the malleus, which is apt to be detached with the growth.

The **Diagnosis** of aural polypi is for the most part easily made; purulent discharge from the ear, and especially hæmorrhage, are the two symptoms which attract the patient's attention. It is of special importance to determine the place of origin of the polypus, whether it springs from the neighbourhood of the membrana tympani, or from this structure itself. Any special sensitiveness of the tumour when touched with a probe is generally indicative of some growth other than polypus, the tissue of which is destitute of nerves. When the membrane itself is in a state of polypoid degeneration, some resistance will be offered to a probe by the handle of the malleus; but a mucous polypus is soft and unresisting, unless it is the seat of calcareous or osseous deposit.

When the polypus is small or elongated, a probe generally enables its root and place of attachment to be detected; but in the case of a large polypus filling the meatus, these parts may be very difficult to ascertain. It is well to adopt Politzer's plan, and to use a blunt probe bent at a right angle near its extremity, and with its anterior end marked by divisions of five millimetres each. The bent portion of the probe is pushed between the polypus and the wall of the canal, and after passing round the larger circumference of the growth, is carefully directed into the deeper parts. When the circular movement of the point of the probe is arrested at a distance less than that of the external orifice from the membrane, it may be concluded that the obstacle is due to the root of the polypus. If the root be met with at 15mm. from the orifice, it is almost certain that the growth originates in the external meatus; when the distance is greater, the growth probably springs from the tympanic cavity. If the polypus be easily movable, the stalk will be narrow and thin; but if the movements be restricted, the pedicle will probably be of an opposite character, and any operation upon it will therefore prove more difficult.

The external appearance of polypi is, to some extent, a guide to their origin. The soft, red, vascular growths, with elevations and depressions like those of a raspberry, generally spring from the tympanum; while the paler and smoother polypi mostly originate in the meatus. It must be remembered that the appearance of polypi changes as time goes on, and with their enlargement. Pressure obliterates the inequalities, and in the course of time even mucous polypi are apt to become paler, owing to the development of layers of epithelium. Swollen and enlarged portions of the mucous membrane of the tympanum, especially over the promontory, may resemble polypous growths, but a probe will serve to detect their true nature. Malignant growths of the tympanum and meatus can scarcely be mistaken for polypi; their surface is rough and ulcerated, and their development is apt to be attended by considerable swelling of the parts around the ear. Such tumours, moreover, rapidly increase in size, and manifestations of cachexia sooner or later set in. A circumscribed abscess of the meatus may in some respects resemble a polypus, inasmuch as it forms a smooth, tense, reddish tumour. It is, however, always attended with pain, which is much increased on pressure, and its development takes place rapidly. The history of the case, examination with a probe, and, if necessary, puncture of the swelling, will prevent any mistake from being made.

The diagnosis is, of course, difficult in those rare cases in which there is a polypus growing from the walls of the tympanum, with the membrane intact. If such a case is seen in an early stage, when the growth is impinging upon the membrane, the latter presents a reddened spot at the point of contact, and becomes gradually bulged out. Perforation then takes place, and the growth protrudes through the opening and into the meatus. Such a tumour might easily be regarded as growing from the membrane itself, unless its progress had been watched. As its size increases, it consists of two parts, connected by a narrow neck at the aperture in the membrane. The size of the projecting portion is no indication of that which is contained in the tympanum, and which may be so large as to require incision of the membrane for its removal. It must not be forgotten that a polypus springing from the mastoid cells may break through the posterior wall of the meatus and appear in that canal. Examination with a probe will show that the pedicle of the growth passes through the bone. Finally, in rare cases, a portion of a cerebral tumour projects into the meatus; but such a growth, with its attendant symptoms, is not likely to be mistaken for a polypus.

Treatment.—In the treatment of aural polypi, the objects to be attained are: 1st, the removal of the cause, whether local or constitutional; and 2nd, the removal of the polypus and the destruction of its root and of granulation tissue around the point of attachment. To fulfil the first indication, the ear must be carefully cleansed, and the treatment recommended for chronic suppurative inflammation must be adopted. Any obvious source of irritation, such as sequestra in the meatus or tympanum, and adenoid growths in the naso-pharynx, should be properly dealt with; while any tuberculous indications will require cod-liver oil, iodide of iron, good diet, and hygienic measures of all kinds.

The *local treatment* of aural polypi consists in various operations for their removal, and in the application of remedies which have an astringent or destructive effect on their tissue. The removal of aural polypi by operation must be at once undertaken whenever symptoms are present indicative of accumulation of pus. These generally appear in the form of convulsive attacks, vertigo, and vomiting. It is also indicated whenever the growth has attained such a size as to fill up the cavity which it occupies. In such a case head-symptoms are very prone to occur. When the conditions just noted are absent, astringent remedies may be first tried. In attempting to remove a polypus, its situation and attachment will guide the operator in selecting the most suitable method. Before any operation, however, the meatus should be carefully cleansed, and then ten to twenty drops of a 10—20 per cent. solution of cocaine, warmed by having been previously placed in hot water (see page 154), should be dropped into it. This will greatly diminish the pain in the subsequent manipulations. The growth may be extracted by means of Wilde's *snare* (Fig. 119) or *forceps*. The former is generally the more convenient instrument. The loop is pushed over the polypus as far as possible, and then tightened until it grasps the pedicle; the polypus should then be detached by a slight jerk, so as to tear it from its detachment. By this method the growth is often removed

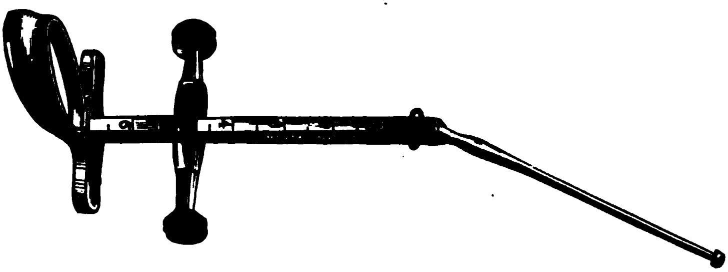


FIG. 119.

WILDE'S SNARE.

almost entirely; whereas, if the loop is tightened too much, it cuts off the polypus at the place at which it has been encircled, and a stump remains. In many cases silk covered with wire, such as is used for the bass string of musical instruments, is better than wire alone, as it does not cut so readily into the polypus. If the root be very firm and resistant, the wire, after being tightened, should be twisted by turning the instrument on its long axis, and then cut off. In a few days the stump will become detached, and will fall out of the ear, or may easily be removed with a pair of forceps.

In dealing with polypi connected with the tympanum, it is sometimes best to use a thin wire loop, and to cut through the pedicle as near as possible to its attachment. Various modifications of Wilde's instrument have been devised. One of the best is Blake's *polypus-snare*, which is provided with a movable metal cannula into which the wire loop can be completely withdrawn. Thin platinum wire is the best for the purpose, and an oval loop can be more readily slipped over a polypus than a round one. The polypus either comes away with the instrument, or may be removed by forceps or syringing. If there be anything more than slight hæmorrhage, it may be checked by injecting hot water, or by inserting a plug of cotton-wool dipped in powdered alum.

One drawback connected with the snare is the uncertainty of being able to remove the polypus close to or at its attachment. It is seldom possible so to adjust the wire that constriction takes place at the farther extremity of the pedicle; the tendency is for this structure to be cut through near the polypus, or for the latter itself to be divided, even when care has been taken to tear it away at its origin. Under these circumstances, portions of the growth remain, and unless dealt with may be the starting-points of new tumours. After removal, the ear should be carefully examined, in order to ascertain the condition of the parts at the base of the growth. If any remains of the pedicle are apparent, or if small masses of granulation tissue surround the point of attachment, a strong solution of chromic acid, or a small circular knife, and in exceptional cases the galvano-cautery, may be employed for their removal. A curette (Fig. 120) is also suitable in many cases. Politzer recommends a *knife* in the form of a concavo-convex ring, with a very sharp inner margin, and attached to a steel handle.

The *same instrument* is suitable for the removal of small polypi and granulations in the meatus. When introduced, its convex surface is to be pressed against the growth, until a firm base is felt. The tumour which protrudes through the ring is cut through as the instrument is withdrawn, and comes away on the concavity of the knife. Larger polypi may also be removed by the same instrument, used so as to divide the root.

In some cases, the growth can be removed by the aid of a small *round sharp scoop;* this is pushed down to the root of the polypus, and the division of its attachment is effected from behind. This method is suitable only for the removal of polypi of the meatus with soft stalks and loosely attached to their base. Polypi of this character are sometimes capable of being removed by forcible syringing.

Crushing by means of *forceps* is another mechanical method of removing polypi. It has been tried for dealing with large growths, which cannot be entirely removed by any of the methods already described, and for portions of growths remaining after operations. A pair of dressing-forceps, suitably curved, is used to crush the tissue of the growths, and several portions may be dealt with in succession, provided that the hæmorrhage does not obstruct the view. After the operation upon tympanic growths, it is well to introduce plugs of cotton-wool, covered with finely powdered alum. The pressure, coupled with the astringent effects of the alum, will tend to cause atrophy of any remaining portions.

FIG. 120.

BARKER'S AURAL CURETTES.

The *galvano-cautery* is sometimes used for the removal of those polypi which, owing to the firmness of their pedicles, cannot be dealt with by means of the snare. For ordinary polypi, removable by the snare, curette, or the ring-knife, the cautery is not to be recommended, owing to the risk of cicatricial contraction which attends its use. The shape of the cautery should be adapted to the form of the growth. A simple pointed instrument is generally sufficient, but for large growths a small flat surface is desirable. Great care should be taken to avoid burning healthy parts, and especially the walls of the tympanum. The circuit should not be closed until the cautery is in contact with the growth. The number of applications at each sitting and their duration must be regulated by the size and position of the polypus. The vapour evolved should be removed by blowing into the ear as soon as it obstructs the view. Before each successive cauterisation the cautery should be heated so as to destroy any tissue which may adhere to it.

If properly applied, the galvano-cautery causes no bad after-effects; but cases are on record in which facial erysipelas and marked constriction of the meatus, due to cicatrisation, were the results of the application. In another case in which the polypus was situated near the membrana tympani, periostitis, accompanied by severe pain, was caused by the operation.

Caustic and Astringent Applications.—A concentrated solution of *chromic acid* is very efficacious, if applied with proper precautions. Before using it, the surface of the growths should be thoroughly dried, and the acid then applied by means of a chromic acid carrier (Fig. 82, page 283), or a camel-hair brush, or a small piece of cotton-wool twisted tightly on to a probe. Chromic acid has been found efficacious in dealing with large polypi; the application, which is not attended with much pain, should be made about twice a week until the growth has disappeared. For the destruction of multiple deeply-seated polypi, and small granulations and the remains of polypi, after their removal by other means, the author employs a saturated solution of this drug for most cases, the application being usually successful and unattended with risk of injury to other parts. The ear should be syringed if the application causes pain, and in most cases it is well to do so after the solution has been allowed to soak in for a few minutes. *Nitrate of silver* is sometimes used as an application to granulations and to the root of the polypus after removal. Its application is wont to cause somewhat severe and persistent pain, and the slough produced is only superficial. Politzer recommends in preference the *chloride of iron*, as rarely causing severe pain, while it penetrates much more deeply into the tissue even of firm fibrous growths, and more rapidly leads to mortification and detachment. It is applied by dipping the point of a chromic acid carrier or a probe into the liquid, or by means of a small brush, or a piece of cotton-wool, twisted tightly on to a probe, and the cauterisation is to be repeated when the slough is detached by syringing. For hard growths the crystallised chloride has been recommended, a small fragment being taken up with forceps, pushed against the growth, and retained in position by means of a plug of cotton-wool. The salt soon becomes liquefied, and penetrates into the growth, causing a slough of some size. Politzer recommends the crystals of the sesquichloride of iron for hard growths, occupying the entire circumference of the osseous meatus and coming into contact with it all round, so that a probe cannot be passed between the tumour and the wall of the meatus; but in the author's opinion the galvano-cautery is more suitable for such cases, as its action can be better regulated.

Various other caustics have been recommended for the destruction of granulations and the remains of polypi; but such as *potassa fusa* and *nitric acid* are open to the objection that it is impossible to limit their action to the affected part, and that healthy portions of the meatus are liable to be destroyed.

The treatment of polypi by the application of *alcohol*, first recommended more than fifty years ago, has recently been fully tried for both polypi and granulations. Before using it the ear must be carefully cleansed and dried with cotton-wool. A little warmed alcohol is then poured into the meatus, and allowed to remain from fifteen to thirty minutes. The application is to be thus made twice daily, and the treatment regularly continued until the polypus has completely shrivelled up and disappeared; the length of time generally required is several weeks. The treatment is adapted not only for remains of polypi and granulations, but even for large fibrous growths filling up the meatus. Usually pure alcohol causes too much pain to be well borne, and it is therefore best to begin with a 25 per cent. solution and to increase its strength as the parts become accustomed to the application. The previous instillation of a warm 20 per cent. solution of cocaine enables a stronger percentage of alcohol to be used than could otherwise be tolerated.

The action of alcohol upon aural growths is not followed by any bad consequences. The treatment may be carried out by any practitioner, and in not a few cases will be found to be an effective substitute for removal by operation. Inasmuch, however, as the method requires time, it is generally best to remove by operation all polypi which can be thus dealt with, and afterwards to employ the alcohol to produce atrophy of any fragments that remain, if they cannot be reached by chromic acid or the other safe remedies mentioned previously, which are quicker in effecting a cure.

Politzer* thus sums up the cases for which the alcohol treatment is especially adapted.

(1) For the removal of the remains of polypi in the external meatus and on the membrana tympani.

(2) For the treatment of intratympanic polypi, and their remains, which can seldom be entirely removed by operation, are often beyond the reach of instruments, and very often recur.

(3) For multiple granulations of the external meatus and on the membrana tympani.

(4) For diffuse excessive proliferation of the mucous membrane of the tympanum.

(5) For cases in which, on account of mechanical obstacles in the external meatus (exostosis, stricture), the removal of polypi cannot be accomplished with instruments.

(6) In order to avoid operations in persons afraid of them, and in children in whom surgical treatment presents great difficulties, and very often necessitates the aid of anæsthetics.

There is another remedy, viz., *acetate of lead*, which when applied to aural polypi produces very satisfactory results. Moos and Steinbrügge recommend a supersaturated solution, containing from ten to twenty-five per cent. of lead, with the addition of from five to ten drops of acetic acid. This solution is transparent; it is dropped into the ear from a glass pipette, the patient's head being held over the opposite shoulder, and the ear is afterwards plugged with salicylic cotton-wool, in order to keep the solution as long as possible in contact with the affected surface. The application should be made twice daily, after the ear has been thoroughly cleansed. There is sometimes pain, of a stinging or burning character, which, however, soon subsides. The length of time required for the treatment varies; but six weeks is generally sufficient. With regard to the manner in which the lead acts upon the polypus, it appears to cause wasting of the cellular elements and constriction of the blood-vessels. It may be that the lead-solution reaches the interior of the vessels, and causes coagulation and thrombosis, and consequent death of the growth. Comparing the effects of the lead with those of alcohol, Moos and Steinbrügge suggest that the latter is probably more suitable for cases of granulation polypi, and lead for the coarser fibromatous growths. "It is also possible, that in cases of tympanic polypi with minute perforations in the membrane, alcohol may act more favourably on account of its greater power of penetration."

---

* *Lehrbuch der Ohrenheilkunde*, S. 419. See also English Translation of 3rd Edition, p. 541.

CHAPTER XXXII.

CARIES AND NECROSIS OF THE TEMPORAL BONE.

Causes—Cases due to Injuries—Chronic Middle-Ear Suppuration—Constitutional Disorders—Parts most often Involved—Varying Extent of the Processes—Caries of the Ossicles—Necrosis—Subjective Symptoms—Objective Symptoms—Symptoms of Lesions of the Facial Nerve—Paralysis—Perversions of Taste—Character of the Discharge—Examination with a Probe—Course—Diagnosis and Prognosis—Bezold's Statistics—Possible Multiplicity of Complications—Treatment—Special Measures for dealing with Caries and Necrosis of the Ossicles—Removal of the Tympanic Membrane and of the Ossicles through the Meatus—Details of the Operation—Subsequent Treatment—Possible Accidents—Treatment of Chronic Suppuration in the Attic—Stacke's Method—Treatment of Necrosis of the Temporal Bone.

Caries and Necrosis of the temporal bone result, in the majority of cases, from acute and chronic suppurative inflammation of the middle ear, and are most often seen in children. As in other bones, caries is more frequent in the cancellated than in the compact tissue; while the reverse holds good with regard to necrosis. Moreover the latter is more common when the inflammation is acute, whereas caries more often follows a chronic process. In adult cases, discharge from the meatus often exists for many years before there is any evidence of osseous disease. Other causes are rare; but severe injuries to the temporal bone—*e.g.*, from blows or projectiles—may eventually lead to caries and necrosis. Bezold records a case of necrosis of the cochlea in a man aged forty-eight. When seven years old he had been kicked by a horse on the side of the head, and the effects of the injury had been permanent. In a few instances, extensive caries of the temporal bone has resulted from the action of corrosive fluids, poured into the meatus.

It is in those cases of chronic suppuration of the middle ear in which the secretions are retained and decomposed that the ossicles and the bony walls of the cavity are most likely to become involved. Similar complications are prone to occur when the ear-affection is associated with some infectious disorder, as diphtheria, scarlet fever, tuberculosis, or syphilis. Those cases in which the mastoid process and cells are the seat of primary disease would appear to owe their origin to micro-organisms which have passed along the tube from the throat, or have been conveyed by the blood. The pneumatic spaces and the spongy substance of the mastoid portion of the bone are especially favourable spots for the development of micro-organisms, which in many instances are those of tubercle. The osseous lesions may likewise involve the surface, as the result of periostitis, examples of which are common in the mastoid process, and are occasionally seen in the external meatus in cases of otitis externa. In very rare cases, necrosis of the temporal bone is due to suppurative inflammation of the dura mater, which constitutes the periosteum on the internal surface.

The parts of the temporal bone most prone to be attacked by caries and necrosis are: the mastoid process, the posterior superior wall of the external meatus, the roof of the tympanum, and the ossicles, especially the incus and malleus. Less frequently the processes involve the floor of the cavity and the walls of the carotid canal. Occasionally the promontory is the seat of caries. Various portions may be implicated at the same time, and the process may even extend to adjacent bones, *e.g.*, the occipital and parietal. Caries and necrosis of the mastoid portion will be described in the next chapter. Caries occurring in other parts of the bone may be limited to small circumscribed portions of the walls or of the ossicles, or may cause extensive destruction and exfoliation. Between these extremes there are many intermediate degrees, the affected portions being eroded and honeycombed, and generally soft and crumbling, while the inflammatory material undergoes caseous changes. As a result of diphtheria, partial exfoliation of the tympanic ring, with portions of the external meatus and of the mastoid process, is by no means rare in children.

As a result also of hereditary syphilis, suppuration of the middle ear often leads to extensive necrosis, even during the first few months of life.

Caries of the Ossicles results in their destruction and detachment. In some cases the bones come away spontaneously, or after syringing, during the course of severe suppurative inflammation of the middle ear, in which the soft parts perish and the ossicles become free. This result most often occurs in cases of scarlatina. In cases of chronic suppuration, the long process of the incus is the part most liable to be affected by caries; its nutrition is more readily impaired than that of the malleus, which, in a great part of its extent, is closely connected with the highly vascular tympanic membrane. Next in order of frequency come the body of the incus, and the short process, followed by the head, handle, and the neck of the malleus. When the head of the malleus is affected with caries, the process likewise attacks the upper and outer wall of the attic, in which granulations sprout up, while Shrapnell's membrane becomes perforated. In less frequent cases both the head of the malleus and the incus are involved, and the upper half of the membrana tympani is destroyed. The stapes is the least liable to be attacked; but it loses sometimes one and sometimes both crura, while the foot-plate is very seldom involved. While the osseous walls of the tympanum are the seat of caries, fungous granulations always sprout up from the mucous membrane or its remains. The secretion, which is foul-smelling, and irritates the skin of the meatus, often contains the bacilli of tubercle.

Necrosis is the result of destruction of a circumscribed portion of bone, which constitutes a sequestrum. The part involved may be small and quite superficial; or the process may attack large portions of the temporal bone—*e.g.*, the squamous, mastoid, or pyramidal part—and cause their detachment. The labyrinth, being composed of very compact bone, is less frequently implicated; but cases sometimes occur of extensive necrosis of this part, with detachment of the entire cochlea as a result. Most cases of necrosis occur in connection with scarlatina, and children constitute the majority of sufferers. This tendency, as compared with adults, is explained by their proneness to be attacked by acute infective diseases, and also by the comparatively very large size of the labyrinth in early life. It must also be borne in mind that the necrosis may show itself years after the fever.* The sequestrum may remain for some time in the cavity; but sooner or later, it generally moves towards the external meatus, and either escapes or is removed. So long as it remains in the tympanum, it acts as a foreign body, and excites suppuration and fungous granulations. Other possible consequences are: the development of abscesses (from the burrowing of pus); fistulæ; lesions of the cerebral membranes or of the large vascular channels. After removal of a sequestrum, the healing process sets in, and assumes various forms. The newly developed connective tissue may become ossified, and a bony cicatrix results; in other cases, the surface is covered with a membrane within which cholesteatomatous growths may be developed; while in a third class bony formations are the prevailing feature, and the process sometimes goes on to such an extent as to obliterate the cavity of the tympanum, and to obstruct the external meatus.

Subjective Symptoms.—In the majority of cases, caries and necrosis of the temporal bone fail to produce characteristic symptoms. Pain in and about the ear is almost always complained of, and is due to inflammation of the periosteum and retention of secretions. It is generally continuous and violent, but sometimes intermittent. In cases of tuberculosis, the processes may be far advanced without causing any very decided pain. Comparative or even absolute painlessness is a common feature of tuberculous inflammation of the middle ear. When detachment of a sequestrum is in progress, the pain is described as deep down in the ear; it is generally of a boring, tearing character, and very severe, and if a large portion of the bony wall of the tympanum be involved, this symptom may last for many weeks or months. Retention of secretions will cause the pain to become even more severe, and especially if the cerebral meninges are implicated. The pain is accompanied by more or less diminution of hearing-power, giddiness, and noises in the ears of various kinds. These symptoms are, of course, in no way characteristic of caries; they are commonly met with in middle-ear suppuration confined to the soft parts. Their presence and severity will greatly depend upon the seat of the disease and the stage of its progress. Neuralgia of branches of the fifth pair is a not uncommon complication. If the labyrinth be specially involved, vertigo and disturbance of equilibrium will be prominent symptoms.

---

* See cases reported by Bezold, *Archives of Otology*, vol. xvi. p. 312.

Objective Symptoms.—These are likewise of a more or less indefinite character. In the early stages there will be the signs of purulent inflammation of the middle ear, *e.g.*, perforation of the tympanic membrane and more or less discharge; hypertrophy and ulceration of the mucous membrane of the cavity, with granulations and polypoid growths; thickening, swelling, inflammation or ulceration of the floor of the external meatus; enlargement and induration of the lymphatic glands in the neighbourhood of the ear. These symptoms are, however, often present when the osseous walls of the tympanum are not implicated. In exceptional cases of caries, the membrana tympani has been found to be intact. More definite signs of affection of bones are furnished by abscesses which form in various directions, and result from the burrowing of pus towards the front and back of the ear, neck, and throat. The parotid gland and the articulation of the lower jaw are often involved in the suppuration; and when the abscesses communicate directly with the carious bone, fistulous passages are apt to remain long after the pus has been discharged. Such passages originating in the temporal bone, sometimes extend for long distances under the skin, and open on the side of the neck or even towards the shoulder.

Symptoms indicating *lesions of the facial nerve* are of frequent occurrence in cases of caries and necrosis of the temporal bone. The wall of the Fallopian canal and a portion of the nerve itself may be destroyed; and in such cases, facial paralysis will be a prominent symptom. On the other hand, the absence of any such symptoms referable to the nerve does not show that the *canal* in which it runs has remained unaffected. There are several cases on record of partial or complete destruction of the walls of the aquæductus Fallopii, with exposure of the facial nerve, but without any symptoms of paralysis. It must also be borne in mind that facial paralysis may be due to the pressure of exudation within the canal, and even within the tympanum, when any openings exist in the thin layer of bone, separating the cavity from the nerve. Still, in connection with other symptoms, facial paralysis is highly suggestive of carious or necrotic processes involving portions of the temporal bone.

If, after lasting for some time, the paralysis should subside, exudation into the canal may be assumed to have been its cause; but if the paralysis continue, there is probably some osseous lesion. In necrosis of the labyrinth, unless the process be confined to the cochlea, the facial nerve is almost invariably affected. Inasmuch as the aural affection is generally unilateral, the facial paralysis is usually limited to one side. Its degree varies, according to whether the entire nerve or only some of its fasciculi are affected. In the latter case, the paralysis will involve different muscles, *e.g.*, those of the forehead, or those of the side of the face and nose. Sometimes all the muscles supplied by the nerve are slightly affected; in other cases, the paralysis is complete. In some cases, the muscles of the soft palate on the affected side are likewise paralysed.

Various perversions of the sense of taste are wont to accompany these lesions of the facial nerve. The glosso-pharyngeal is the nerve of taste for the posterior part of the tongue; the lingual branch of the fifth for the anterior part of the organ. The latter receives its gustatory fibres from the chorda tympani nerve, which runs with the facial trunk, until just above the stylo-mastoid foramen. When the latter nerve is implicated before the chorda leaves it, the gustatory function is lessened or even abolished in the anterior two-thirds of the tongue on that side; and, in addition to this symptom, though only in rare cases, there may be dryness of the mouth, due to implication of those fibres of the chorda which regulate the secretion of saliva.

In cases of slight paralysis, the electrical reaction of the muscles and branches of the nerve is little changed. In severe forms the faradic reaction is often increased at first; but it is soon reduced to a minimum, while the irritability of the muscles, as tested by the galvanic current, is more or less increased. In advanced cases, the latter current fails to evoke any response.

In addition to the paralysis, secondary contractions and spasmodic twitchings of the muscles sometimes occur; the former being due to the development and induration of connective tissue in the muscles. The course of the complaint depends upon the nature and progress of the aural lesion, and the extent to which the nerve is involved. In some cases recovery is complete; in others, there is permanent paralysis of all or some of the muscles supplied by the nerve. Secondary atrophy is then apt to supervene, and the conjunctiva is subject to attacks of inflammation, owing to the want of power to close the eye.

The **Discharge** from the ear in cases of caries and necrosis is sometimes peculiar. It is muco-purulent and somewhat tenacious; it often contains decided traces of blood, or assumes a brownish-red colour; its odour is intensely disagreeable, and, in the absence of antiseptic measures, poisons the room occupied by the patient. Sometimes it is quite putrid, quickly discolouring silver instruments brought into contact with it. Fragments of bone, some large enough to be seen with the naked eye, are occasionally discoverable. In all cases, the discharge should be examined from time to time with the microscope; if small osseous particles are detected, there can be no doubt as to the nature of the lesion. A negative result of the examination does not disprove the existence of caries.

As in other cases of destruction of bone, the best evidence of the actual condition is afforded by the use of a probe, which should be handled with the greatest care and gentleness, and under the guidance of the eye. Serious consequences might ensue from using the instrument with any degree of force. It is easy to detect carious or necrosed bone when the disease is situated in the meatus, the inner wall of the tympanum, or perhaps in the upper part, under the roof, when Shrapnell's membrane is perforated. Failure to detect caries must not be held to imply that the bone is not affected, for the diseased part may be inaccessible to the most careful examination. Indeed, in not a few cases in which the symptoms point to caries, the diseased spot cannot be reached by a probe. The instrument should be bent in various ways according to circumstances, and should have a well-rounded head. Sometimes the meatus is occupied by polypoid excrescences, which spring from the mastoid antrum, and project through openings in the posterior wall of the canal. Caries and necrosis in the mastoid process may involve the external layer of bone, and in that case masses of granulation tissue will be seen to sprout through the integument. These surround and cover up fistulous openings, through which, if a probe be introduced, softened or necrosed bone, or a loose sequestrum, may be more or less easily felt. If water be injected into the meatus, a few drops, or even a thin stream, will be seen to issue from the external fistulous opening, bringing with them inspissated or caseous masses of pus.

The **Course** pursued by caries and necrosis of the temporal bone, following middle-ear suppuration, varies greatly in different cases; but it is only in a minority that favourable results can be anticipated. The progress of the osseous disease is, however, sometimes very slow; there may be long intervals during which some little improvement may seem to be going on. In young subjects the process is usually more rapid than in adults; sequestra are speedily formed and detached, large portions of the mastoid process often become exfoliated, and in severe cases nearly the whole of the temporal bone is destroyed. In not a few cases, symptoms of cerebral or meningeal disease suddenly become developed, while in others a fatal issue is due to phlebitis and thrombosis of the lateral sinus. Pyæmia is another accident liable to occur in these cases. If, as sometimes happens, the carotid canal be invaded, fatal hæmorrhage is likely to ensue. Such an accident would be a more frequent complication of caries, were it not for the fact that during chronic suppuration, progressive development of connective tissue usually takes place. This process is succeeded by partial ossification, and the diseased portions of tissue are thus to some extent isolated.

Diagnosis.—This is sometimes very difficult, and in many instances it is necessary to keep the patient under observation for a long time before a definite opinion can be given. If, when a probe is introduced, roughened bone can be felt, or a portion of bone which is clearly movable and denuded of its periosteum, the nature of the case will be of course evident. But the affected part may be inaccessible, and the negative result of probing is, therefore, of no great value. In the absence of the positive evidence which a probe often yields, caries or necrosis may be suspected to exist when the following symptoms are present:—

1. A long-continued purulent discharge from the meatus, varying in consistence, offensive in character, often coloured with blood, and not yielding to ordinary treatment carefully conducted. The discharge may be temporarily arrested by granulations and sequestra, and also by projection of the walls of the meatus.

2. The constant re-appearance of granulations in the same place in which they have been destroyed.

3. The previous escape of small sequestra or particles of bone.

4. Erosions of the osseous wall of the meatus, and fistulous

openings behind the ear, with an intermittently copious and offensive discharge therefrom.

5. The formation of abscesses in the neighbourhood of the ear and in the side of the neck, and swelling of the lymphatic glands.

6. Perforation of the tympanic membrane at its upper part, the opening having a crater-like appearance, and giving exit to very offensive secretion.

7. Severe lancinating pain in the deeper part of the ear, and extending over the side of the head.

Prognosis.—Any opinion as to the probable results in cases of caries of the temporal bone must be given with great caution. As a general rule, when the lesion is due to injury, the prognosis is more favourable than when it has supervened upon suppurative inflammation. In all cases, if the general health be good, the process slight and confined to the mastoid portion, if there be free vent for all discharges, and if exfoliation take place, there is reason to anticipate a favourable issue. In some instances, patients with caries of the temporal bone attain a ripe age, and die from disease unconnected with the local affection. While, however, caries is in progress, there is always the possibility of extension to some important part, with serious results, as already described. There is also the risk of pyæmia, general exhaustion, or pulmonary tuberculosis. In tuberculous, syphilitic, and diabetic subjects, the prognosis is always more or less unfavourable. The degree to which the hearing-power is affected depends upon the seat and extent of the osseous lesions. If the latter be confined to the mastoid portion, the hearing may be almost or quite normal: on the other hand, necrosis of the labyrinth will involve total deafness.

Bezold's* list contains forty-six cases of necrosis of the labyrinth. Of these, nine died, all but two from "implication of the neighbouring meningeal and cerebral regions, extension of the suppurative process taking place from the posterior surface of the pyramid, corresponding to the position of the *porus acusticus internus*. The cerebellum was most frequently involved." Septic phlebitis was demonstrated in two cases. Of the thirty-seven cases in which the issue was favourable, in twenty-nine the sequestrum was removed through the auditory canal; in seven it was extracted through fistulæ in the mastoid portion; in the remaining case, it was said to have passed through the tube. With regard to the prognosis in cases in which the Fallopian canal is implicated, Bezold thinks there is great probability of restoration of the function of the divided facial nerve even after extensive loss of substance.

---

* *Archives of Otology*, vol. xvi. p. 346.

It must be borne in mind that caries, as a result of suppurative inflammation of the middle ear, may spread so as to involve several important parts at the same time. Thus in a fatal case, reported by Hedinger,* there was a sub-dural abscess, thrombi and ulceration of the superior petrosal sinus, and ulceration leading into the lateral sinus. The external auditory canal was narrowed to a mere slit, and the bony portion was carious. In this case, pus had been discharged into both the lateral and the superior petrosal sinuses. A case of caries of the tympanum, with fatal hæmorrhage from the carotid, is recorded by Drs. Moos and Steinbrügge.† There was an opening 15mm. in breadth and 7mm. in height in the external bony wall of the carotid canal. The artery was bare to the whole extent of this opening, and corroded and perforated near the promontory. The case was remarkable not only for the lesion of the artery, but because of the rapidity with which the entire series of processes had become developed. The time occupied was only four months.

Treatment.—This must at first be directed towards the improvement of the condition of the middle ear, and this object may be attained by the use of antiseptic remedies and great cleanliness. Supposing that caries is known or strongly suspected to exist, the treatment should be still more energetically carried out, and every effort should be made to remove secretion and prevent its accumulation. It is all-important to remove luxuriant granulations, so as to provide for the escape not only of secretion, but of dead particles of bone. If there be only one or two small perforations in the membrane, it is desirable that these should be enlarged by incision, so as to afford a free passage. Polypoid growths should be removed by Wilde's snare, or by applications of a concentrated solution of chromic acid, after which as strong a solution of alcohol as can be borne should be introduced into the ear.

---

* *Archives of Otology*, vol. xiii. p. 42.

† *Ibid.*, vol. xiii. p. 160.

When the granulations have been thus dealt with, antiseptics and astringents of various kinds will come into use (see page 450, *et seq.*). Powdered boric acid, introduced by means of an insufflator, is a very good remedy. The objections sometimes raised against it, on the ground that it causes the secretions to be retained, are without real foundation. If fluids be preferred, they should be injected through a small tympanic tube, which can be passed into the tympanum. Fluids also may be introduced through the Eustachian tube by the aid of a catheter; a considerable amount of secretion may sometimes thus be driven out through the meatus. The air-douche likewise fulfils a similar purpose.

When carious spots are visible and accessible—*e.g.*, in the meatus—improvement may be effected by scraping them with a curette, or in some cases by touching them with carbolic acid or a concentrated solution of chromic acid, or with the galvano-cautery. The local application of a solution of lactic acid (15—20 per cent.) sometimes proves serviceable in cases of circumscribed ulceration of the inner wall of the tympanum. The applications cause the detachment of small sequestra, but are apt to produce more or less severe pain. Dr. Ole Bull,* of Christiania, recommended the application of the mineral acids, hydrochloric and nitric, for the removal of diseased bone. The acids act by rendering the bone capable of absorption. As the result of many trials, Dr. Bull found that hydrochloric acid was the best solvent for the earthy particles; his method was to soak small pieces of cotton in a solution of hydrochloric acid (2—4 per cent.), and lay them on visible portions of diseased bone. The cotton was allowed to remain for twenty-four hours, and then removed. The applications were continued at intervals until discharge ceased; the vacant place in the bone was then found to be occupied by a soft mass, presumably cartilage, proceeding from the bone bordering the dead part. The treatment was sometimes continued for three or four months.

There are, however, obvious dangers connected with the application of acids within the tympanum, and the object aimed at can be attained more rapidly and with less risk by the use of a sharp curette or spoon. This treatment is well adapted for the removal of small, circumscribed patches of diseased bone from the inner wall of the tympanum. There is, of course, less difficulty in dealing with caries of the mastoid portion or external meatus. Even here, however, good results can be obtained only when a small area of bone is diseased. Special care is necessary when removal of diseased bone from any part of the tympanum is the object in view. The treatment of caries and necrosis of the mastoid process will be described in a subsequent chapter.

---

* *Archives of Otology*, vol. xviii. p. 123, and vol. xxviii. p. 13.

It remains to consider the treatment of those cases in which, as frequently happens, caries of the ossicles is associated with disease of the roof and walls of the tympanum, and of the mastoid antrum and cells. Masses of cholesteatomatous material, inspissated pus and granulation tissue, are often found in the mastoid antrum and aditus, as well as in the attic. It is often difficult, and sometimes impossible, thoroughly to remove these masses from the attic by means of any operation through the meatus; and when the aditus and antrum are implicated, any such attempt would obviously be futile. When suppuration has existed for some time in the middle ear, its walls are apt to become infiltrated with pus, and sinuses may extend from either the tympanum or the mastoid antrum into the contiguous bony tissue. Under such conditions, the mere removal of the ossicles will result in little, if any, benefit. On the other hand, laying open the mastoid antrum, aditus, and tympanum, so as to convert them into one cavity, has the advantage of permitting a thorough examination of the parts. Such an operation is not attended with more risk, and the subsequent amount of hearing is not less than when only the tympanum is exposed. If the discharge still continue after the ossicles alone have been removed through the meatus, and the tympanum thus exposed, a further operation must be undertaken to discover the cause, and the mastoid antrum and aditus will have to be opened. Such a course of procedure would involve a two-fold drawback, viz., a second operation and loss of time. Taking all these circumstances into consideration, whenever the ossicles have to be removed, the author opens the mastoid antrum, aditus, and tympanum. Of late, he has supplemented the operation by lining the cavity with epithelium, as suggested by Mr. Ballance. A description of this operation will be found in the next chapter.

Although the removal of the ossicles through the meatus, except in special cases, and the opening of the tympanum alone are not recommended, these procedures are still adopted by some surgeons: it therefore seems desirable to give an account of the methods usually employed.

Removal of the malleus and incus through the meatus is impracticable if there be any decided constriction of the meatus. If the canal be patent, the operation will, in most cases, present no great difficulty. The patient must be fully under the influence of an anæsthetic; and thorough illumination must be obtained either by sunlight, by the employment of reflected artificial light, or the electric forehead lamp. The special instruments required are: a tenotome for cutting the membrane and tendon of the tensor tympani, a hook for drawing down the incus, a Wilde's snare, a foreign body forceps, a sterilised syringe, and a large number of cotton-holders, ready for use. Disinfection of the auricle and meatus by means of a solution of biniodide or of perchloride of mercury (1 to 1,000) should be effected at least an hour before the operation is commenced, and the ear afterwards covered over with a pad of sterilised wool. When a large portion of the tympanic membrane still remains, and is much indrawn, but movable, it is well to use the air-douche through the catheter, in order to withdraw the membrane as far as possible from the inner wall of the cavity.

The steps of the operation consist in detaching the membrane at its circumference; dividing the tendon of the tensor tympani, cutting through the articulation between the incus and the stapes, and removing the malleus and incus with the forceps or wire loop. When nearly the whole of the tympanic membrane still exists, an opening should be made in the middle of the lower margin, and carried upwards, first on one side and then on the other, to a corresponding point above, keeping the knife close to the edge of the meatus. The next step is the division of the tendon of the tensor tympani muscle, and of the articulation between the incus and the stapes. Division of the tendon has been already described (see page 400). To disarticulate the incus, the hook-knife should be passed close behind the long process of the bone, in a downward direction, until an obstacle is reached. The cutting edge of the instrument is then brought over the joint, which is severed by gentle pressure. If the division has been properly effected, the bone will be found loose and movable, when an attempt is made to draw it outwards with the hook. The extraction of the malleus is next to be accomplished. The bone and the remains of the tympanic membrane should be seized with the loop passed as high as possible into the cavity, and traction should be made in a direction downwards and outwards, in order to bring the head of the bone over the margin of the outer wall of the attic.

Owing to its peculiar position, much more difficulty will be experienced in the extraction of the incus, the greater part of which lies in the attic. It has therefore to be displaced downwards, so that when it becomes visible, it can be removed with the snare or bent forceps. In using a hook to displace the bone, it is necessary to avoid injuring the stapes and the facial canal: the operation is by no means free from danger. As a preliminary measure, hæmorrhage should be carefully arrested, so that the deeper parts can be clearly seen. The hook is passed along the superior wall of the meatus, into the space previously occupied by the head of the malleus. Its point is directed upwards, and its border, which forms a right angle with the shaft, is brought into contact with the internal surface of the osseous portion of the outer wall of the tympanum. The hook is then turned backwards and downwards, through half a circle, being kept as close as possible to the wall of the attic. If this manœuvre be successful, the point of the hook will catch the saddle of the incus and bring the ossicle to the floor of the tympanum, whence it may be removed either by the forceps or by using the syringe. The hook may be caught by the wall of an abnormally narrow aditus, in which case, it should be gently withdrawn and used as a probe in order to discover the position of the incus.

During the operation, the blood should be rapidly mopped up by cotton-wool attached to holders. The cavity is then to be irrigated with a warm solution of boric acid or of perchloride of mercury. After the parts have been dried with cotton-wool, insufflation of powdered iodol or of boric acid, and the application of gauze covered by a bandage will complete the dressing. This is to be renewed in from twenty-four to forty-eight hours; and if the discharge consist mainly of serum with a little blood, dry cleansing will suffice. So long as the discharge continues, the dressing must be changed daily. In the majority of cases, a new tympanic membrane becomes developed in the course of a few weeks; it is often deficient in the upper part.

The chorda tympani may be stretched or perhaps torn across during the operation; but even in the latter case, restoration of function may eventually occur. Injury to the trunk of the facial nerve may also be caused by the operation: removal of the incus is especially liable to be thus complicated. The paralysis which follows is not necessarily permanent. The operation has, in some cases, been followed by vertigo, nausea, and vomiting, probably due to displacement of the stapes and injury to the labyrinth.

Treatment of Chronic Suppuration in the Attic of the Tympanum.—When there are symptoms of chronic suppuration within the attic of the tympanum, and an opening in the membrane exists above the short process, the careful use of a syringe and the removal of inspissated exudation may serve to reveal granulations and carious spots to which remedies can be directly applied. When only a small perforation is visible, the ordinary syringe should be replaced by the tympanic irrigator (see page 446), which can be passed through the opening (enlarged, if necessary) into the attic. The insufflation of boric acid constitutes the best treatment after the parts have been thoroughly cleansed with antiseptic solutions. No good result can be expected from local applications when the bone towards the mastoid antrum is affected.

Should the symptoms continue after a fair trial of ordinary measures, an operation, devised by Stacke,* is still advocated by various authorities. It consists in the removal of the ossicles, after detaching the auricle and soft structures of the meatus, and chiselling away the outer wall of the attic and the inner portion of the osseous meatus, superiorly and posteriorly. Its author claimed that it enabled the surgeon to deal effectually with cases of severe suppuration within the attic and with the causes thereof. He laid down the following indications for its performance: (*a*) obstinate suppuration within the attic, unchecked by removal of the malleus and incus; (*b*) the presence of cholesteatoma; (*c*) caries of the walls of the attic, this last being characterised by fistulous openings or larger gaps in or above the superior osseous margin.

To expose the attic, a vertical incision, slightly curved above, is made about two-fifths of an inch behind the line of insertion of the auricle, and parallel to it. It should be from one-and-a-half to two inches in length, and extend nearly as far as the most prominent portion of the mastoid process. The next step is to detach the soft structures with a raspatory from the osseous canal, and divide the upper, posterior, and inferior walls of the membranous meatus and turn them forwards with the auricle. If the tympanic membrane be then visible, it must be cut through at its circumference and removed. Then the chisel, directed upwards and guided by a probe, is used to take away the inner portion of the upper wall of the meatus and the posterior osseous ring of the tympanic membrane, so that the upper tympanic cavity is fully opened.

---

* *Archiv f. Ohrenheilkunde*, xxxi. S. 201; xxxiii. S. 120, 322.

When every prominent portion of the superior and posterior boundary of the meatus has been chiselled away, the ossicles are freely exposed, and may be easily removed after tenotomy of the tensor tympani muscle and division of the articulation between the incus and stapes. The surgeon then obtains a clear view of all the walls of the attic, even of the upper one (the tegmen tympani), and can, if necessary, remove from it carious particles with a curette, having a suitable curve in the handle.

After all diseased tissue has been scraped away, and the wound irrigated with a 2 per cent. solution of carbolic acid, the meatus is replaced and sutures are applied to the posterior wound. To assist to fill the cavity left by the removal of the wall of the meatus, a flap may be cut and applied as described in Chap. XXXIII. To prevent constriction the meatus is packed with a narrow strip of iodoform gauze. A pad of iodoform gauze, covered with wool, is then applied to the ear. In from four to six days, the dressing may be removed: sometimes the meatus is found in proper position and thoroughly covering the bone. But in most cases, granulation tissue is visible in the deeper portion; and in order to prevent constriction, it is necessary to continue to use sterilised gauze as a tampon, and often to cauterise sprouting granulations. Until healing is complete, the tampons should be changed daily. When secretion is abundant, it is advisable to wash out the cavity by means of the intra-tympanic irrigator, and by using a syringe to the wound. When the secretion is only slight, dry cleansing with carbolised cotton-wool will be sufficient. Sometimes the meatus remains constantly moist, as the result of an new tympanic membrane becomes developed in the course of few weeks; it is often deficient in the upper part.

The chorda tympani may be stretched or perhaps torn acr during the operation; but even in the latter case, restoratio function may eventually occur. Injury to the trunk of the nerve may also be caused by the operation: removal of the is especially liable to be thus complicated. The paralysis follows is not necessarily permanent. The operation has, in cases, been followed by vertigo, nausea, and vomiting, due to displacement of the stapes and injury to the lab

Treatment of Chronic Suppuration in the Attic of the Ty —When there are symptoms of chronic suppuration attic of the tympanum, and an opening in the memb above the short process, the careful use of a syrin removal of inspissated exudation may serve to reveal and carious spots to which remedies can be dir When only a small perforation is visible, the ord should be replaced by the tympanic irrigator which can be passed through the opening (enlarg into the attic. The insufflation of boric acid con treatment after the parts have been thorough antiseptic solutions. No good result can be ex applications when the bone towards the affected.

Should the symptoms continue after a fa measures, an operation, devised by Stacke,* various authorities. It consists in the rem after detaching the auricle and soft struc and chiselling away the outer wall of th portion of the osseous meatus, superiorly author claimed that it enabled the surg with cases of severe suppuration within causes thereof. He laid down the follo performance: (*a*) obstinate suppuratio checked by removal of the malleus an of cholesteatoma; (*c*) caries of the wa being characterised by fistulous open above the superior osseous margin.

To expose the attic, a vertical in

---

* *Archiv f. Ohrenheilkunde*, xxxi.

CHAPTER XXXIII.

AFFECTIONS OF THE MASTOID PROCESS.

Variations in the Mastoid Cells—Inflammation of the Mastoid Process—Mastoid Periostitis—Inflammation of the Mastoid Cells—Acute and Chronic Forms—Causes and Morbid Appearances—Symptoms and Course—Caries and Necrosis of Mastoid Process—Course and Consequences—Prognosis—Treatment—Operation in Acute Suppuration in Mastoid Process—Indications for Operations in Chronic Suppuration—Various Conditions of the Surface of the Bone and of the Subjacent Tissue—Anatomical Relations of the Mastoid Process—Summary of Indications and Objects of the Operation—Details of the Operation—Preparation of the Patient—Instruments Required—Position of Patient—The Operation—Exposure of the Attic and of the Mastoid Cells—Formation of a Flap partially to Line the Cavity—Mr. Ballance's Grafting Operation—Accidents and Complications which may Occur during the Operation—Results and Prognosis—Prospect as to Hearing-Power.

Variations in the Mastoid Cells.—The cellular spaces of the mastoid process are sometimes increased in size; and in rare specimens, owing to atrophy of the septa, the process may be found to contain a single large cavity. In another class, the cells are smaller than usual in consequence of thickening of the mucous membrane, or of abnormal growth of the osseous tissue. In the latter case, the cellular structure may be altogether obliterated, and the mastoid process converted into a solid bony mass. This change is not infrequent in advanced life. Sometimes abnormal communications exist between the mastoid cells and the cellular structure of adjacent bones; thus, the cells of the mastoid portion may open into those of the basilar process of the occipital. Owing to defective ossification, a fissure occasionally separates the mastoid from the squamous portion, and by this eczematous eruption. This [illegible] applying a 3 per cent. solu [illegible]

The average time requi [illegible] process is about two mont [illegible] ably reduced by the appl [illegible] in the next chapter. R [illegible] that portions of diseas [illegible] sitate a repetition of th [illegible] lessened by the opera [illegible]

As already men [illegible] the [illegible] Stacke's method [illegible] efficient treatmen [illegible] is mainly caries of the oss [illegible] are far more s [illegible] of antrum and [illegible] of the and the tymp [illegible]

The treat [illegible] [illegible] the tissues. [illegible] the skin [illegible] application [illegible] the surface [illegible] the skin is raised [illegible] and [illegible] a [illegible] than [illegible] treated [illegible] derivatives [illegible] in [illegible] occurred [illegible] as an independent affection,* and is usually the result of extension from adjacent parts. It may of course be set up by direct injuries to the process. It is a not infrequent consequence of extension of periosteal inflammation from the external auditory meatus, and of suppurative inflammation of the middle ear, involving the mastoid cells. In the latter case, the morbid process may also affect the osseous lamina, or may leave it intact. Whenever fissures or cracks exist in the bone, a deeply-seated inflammation may easily spread to the superficial parts. When free escape of the discharge is impeded, suppurative processes in the middle ear are very liable to extend to the mastoid cells. Small perforations in the upper part of the membrane and constrictions of the meatus are common obstacles of this nature. In young children, periostitis of the middle ear sometimes extends rapidly to the external meatus and thence to the mastoid process.

The **Objective Symptoms** of mastoid periostitis vary in degree according to the extent of tissue involved. The inflammation may spread over the whole mastoid region, and even upwards and forwards towards the temple. The parts behind the ear are red and swollen, and the auricle stands out from the head. When due to inflammation of the mastoid cells, the swelling is somewhat defined in the early stages, but afterwards becomes diffused; sometimes the upper part of the sterno-cleido-mastoid is stiff and swollen; the head is turned towards the opposite side and kept in that position. There may be more or less marked symptoms in the meatus, *e.g.*, redness, swelling, and perhaps discharge of pus. Even when pus has formed, the swelling behind the ear is generally boggy to the touch, without giving any distinct sensation of fluctuation. The development of the inflammation is not infrequently accompanied by rigors, which are succeeded by high fever; pain is always severe, and is apt to radiate in various directions. The entire surface of the part is excessively tender. Hearing is not interfered with unless the meatus be at the same time affected. In rare cases, mastoid periostitis runs its course without pain, and with local symptoms of an apparently slight nature† until an abscess forms, which, on being opened, is found to communicate with a portion of exposed bone. Sometimes, even after pus has formed, the osseous surface is merely roughened and slightly eroded.

---

* A case, presumably of primary origin, is reported in the *Archives of Otology*, vol. xiii. p. 22. See also other cases in same journal, vol. xix. p. 95.

† See a case recorded by Dr. F. M. Wilson in *Archives of Otology*, vol. xiv. p. 25.

Mastoid periostitis may terminate in resolution without suppuration; and even after pus has formed, the abscess may burst externally, or the pus may be discharged from an opening artificially made, with no further ill consequences. Caries of the subjacent bone is, however, likely to occur in children, and portions of the external layer sometimes become necrotic. The pus sometimes finds its way into the external meatus, through a fissure in the cartilage.

The **Diagnosis** is, for the most part, easily made, as the local symptoms are generally distinct. After the abscess has burst or been opened artificially, a probe should be used to determine whether the bone is exposed. Furuncular inflammation and enlargement of a gland close to the mastoid process may cause redness and swelling behind the ear; but such cases can always be discriminated by careful examination. Chronic periosteal inflammation and a succession of abscesses are indicative of caries or necrosis of the mastoid process.

The **Treatment** resembles that of phlegmonous inflammation, and should be energetically carried out. The application of leeches should be followed by that of cold (by means of an ice-bag or Leiter's apparatus). If the inflammatory symptoms do not subside within two or three days, an incision should be made down to the bone. This latter step should be taken at once if fluctuation be detected when the case is first seen. After incision, the condition of the bone can be determined; and if any sinuses exist, or there is evidence of deep-seated inflammation, the mastoid cells should be exposed and their condition examined. If the abscess point in the external meatus, an incision should be made there.

Inflammation of the Mastoid Cells.—This occurs in two forms: (*a*) acute and (*b*) chronic; the former is very rare as a primary affection, but it may occur as a consequence of cold or of direct injury; it is most frequently the result of extension of inflammation from the tympanum, and it sometimes follows inflammation of the external meatus. Foreign bodies in the external meatus not infrequently injure the membrana tympani; the mischief may extend to the middle ear, causing suppurative inflammation, and this in turn may spread to the mastoid cells.

The mucous lining of the mastoid cells is continuous with that of the tympanic cavity, and morbid secretion easily finds its way from the latter to the former, and is especially apt to be retained in those cells which have a vertical direction. Politzer thinks that in cases of supposed primary inflammation of the mastoid cells, the attack is really due to bacterial infection from the naso-pharynx. He suggests that the microbes in the tympanic cavity may perish, while those in the mastoid process may increase in virulence owing to favourable conditions for development. When the tympanic membrane is perforated, inflammation of the middle ear and acute mastoiditis may be set up by the entrance of water containing infective microbes and particles of organic and inorganic matter. Hence the subjects of perforation, when bathing in the sea or in rivers, should insert an ear protector (see Fig. 98, page 366) or a plug of oiled cotton-wool into the meatus before immersing the head. Sea-water is to be regarded as especially dangerous, unless this precaution be taken.

It is probable that the mastoid cells are more frequently affected in middle-ear suppuration than is generally supposed. In fatal cases of the latter disease, the walls of the cells are almost invariably reddened and swollen, while the spaces are occupied by sero-mucous or bloody secretion, or by fluid or inspissated pus. Bezold* states that 9 per cent. of all cases of acute middle-ear suppuration are accompanied by mastoid suppuration to such an extent as to make spontaneous recovery improbable.

It has been already stated that the mastoid cells are especially liable to be implicated whenever an obstacle exists to the free escape of secretion. Such impediments, in the form of granulations, polypi, and membranous bands, are by no means infrequent. Retention of secretions is also likely to occur when the perforation is small and situated in the upper portion of the membrane, and when the external meatus is constricted. In cases of scarlatina, tuberculosis, syphilis, and influenza, there would seem to be a special tendency towards the implication of the mastoid cells. Recent investigations have shown that the spread of the process is mainly due to the action of micro-organisms (streptococci and diplococci), which are often found in the secretion in complicated cases of middle-ear inflammation.

---

* *Ueberschau über den gegenwärtigen Stand der Ohrenheilkunde*, S. 104.

The chronic forms of mastoiditis are associated with various morbid processes, such as caries and necrosis, accumulation of débris (caseous and cholesteatomatous) in the tympanic cavities, induration of the osseous tissue, and obliteration of the cells. All these processes lead to more or less serious results; and their successful treatment is far more tedious and difficult than that of acute suppuration within the mastoid process.

Morbid Appearances.—These, as mentioned above, consist of swelling and hyperæmia of the lining membrane, and accumulation of secretion in the mastoid cells, sometimes to such an extent as to fill them up completely. These appearances are generally most prominent in the antrum; but in severe cases the entire system of cells is occupied by fluids, which take the place of air, while the spaces and their communications are much reduced in size owing to the swelling of the mucous membrane. The inflammation may be limited to the mucoperiosteal membrane, or may extend to the osseous walls of the cells.

When the secretion occupying the cells is largely purulent, the condition resembles that of an abscess which may either communicate with the tympanic cavity or be separated therefrom by membranous formations. Caries and necrosis are the usual results; these processes are more common in the mastoid portion than in any other part of the temporal bone, and children constitute the majority of the patients. The development of cholesteatomatous masses is another frequent consequence; as a morbid process affecting the tympanum, it has been already described (see page 484). The anatomical structure of the part facilitates the extension of morbid processes. The inflammation of the mucous membrane lining the cells tends to involve the osseous tissue, and retention of exudation is favoured by the arrangement of the cells and the minuteness of the orifices by which they communicate with each other. Necrosis may affect portions in the interior of the process, or of the internal or external surface. Periostitis, with purulent effusion separating the membrane from the bone, generally precedes necrosis of the external layer. In severe cases the greater part of the mastoid process is eventually detached as a sequestrum, and sometimes the bony wall of the sigmoid sinus is similarly affected. During its progress, the disease of the bone causes abscesses and fistulous openings to be formed in the soft parts. Such openings are most often found on the surface of the process and in the posterior wall of the meatus. Far less frequently, the bone on the inner surface of the mastoid process becomes involved; and an opening forms in that situation. The pus may burrow inwards and downwards in the connective tissue of the neck, and openings may form as low down as the scapula and even in the axilla. In rare cases of this kind, burrowing takes place in a backward direction, and a swelling forms beneath the upper part of the trapezius muscle. A more serious condition of things occurs when the pus makes its way towards the cranial cavity, where it may set up sub-dural abscess, meningitis, cerebral abscess, or thrombosis of the lateral sinus. Owing to the free communication with the sinus by means of the mastoid veins, extension of inflammation to the former part may easily take place. In yet another class of cases the suppuration involves the external semi-circular canal and the internal ear, and purulent secretion may also find its way into the cranium along the connective tissue occupying the loop formed by the superior canal. Under this latter part in the young subject an irregular opening often exists (the *hiatus subarcuatus*), having an external aperture on the posterior surface of the petrous portion below the groove for the superior petrosal sinus, and on a plane behind the meatus.

When a large portion of the mastoid process has been destroyed, the brain-substance itself may be exposed, as in a case recorded by Kuhn.* The patient was a girl, aged eight, the subject of middle-ear suppuration associated with scarlatina.

Inflammation of the mastoid cells does not always result in caries or necrosis. In some cases of a chronic type, the process induces a hyperplasia of the walls of the cells, and finally a complete sclerosis of this portion of the bone. The cells, whether diploetic or pneumatic, are gradually filled up by bony growth. Sometimes the periosteum is likewise implicated, and the surface of the bone becomes roughened or studded over with many prominences. In such cases, the walls of the tympanum itself are not infrequently thickened by osseous deposits.

Symptoms.—These vary with the cause and degree of the inflammation. When resulting from the extension of suppurative processes from the tympanum, they may for some time be masked by those of the original affection. They may either precede or follow perforation of the tympanic membrane. The patient complains perhaps of a feeling of fulness or uneasiness in the mastoid process, or the part may be swollen and hot, and excessively painful and tender. These local signs may extend for some distance around the process. More or less fever and headache are generally present; the pain is aggravated by movements of the head, and severe exacerbations are apt to occur at night. In some cases, however, in which the mastoid cells contain a considerable amount of pus, there is a remarkable absence of symptoms (tenderness, heat, and swelling) in the process itself, though there may be severe pain in other parts of the head. If, as generally happens, the external parts are simultaneously involved, the symptoms already described (see page 529) will be more or less conspicuous. The meatus is usually swollen; its upper and posterior walls are often tense and prominent. A diminution of the discharge is a common symptom, and is generally indicative of some obstruction in the meatus or tympanum. The perforation is most often situated in the posterior superior quadrant of the membrane. Inflammation in the interior of the mastoid process has been observed to occur several weeks after the apparent termination of acute inflammation and suppuration in the tympanum; but so long an interval is quite an exception to the rule. In another class of cases, the mastoid affection coincides with some exacerbation of the original disease.

---

* *Ueber Prolapsus Cerebelli Durch Cariöse Lücken*, A.f.O. xxvi. S. 56.

The Course of the affection varies considerably in different cases. When due to acute suppuration, to injury, or to the presence of a foreign body in the meatus, the inflammation may rapidly assume a serious form and extend to the membranes of the brain, with a fatal result within a few days. On the other hand, under proper treatment, the inflammation may subside within a week or ten days; but in neglected cases the course is apt to be long and tedious, and disease of the bones (caries or necrosis, or both) is liable to set in. The process may continue in the mastoid cells for some time after the original affection has subsided, and without causing any observable symptoms. The periosteum, in chronic cases, often becomes *thick* and rough.

In severe cases, the most common course is the formation of an abscess in the bone, and this again is followed by necrosis and caries, affecting either the deep or superficial layers. These consequences (which are not uncommon in otitis due to influenza) are sometimes averted by the escape of the pus into the tympanum and auditory meatus; but the mastoid cells are often cut off from the former cavity by caseous or granulation masses which block up the antrum. In the absence of treatment, the pus usually finds its way to the surface of the process, and one or more openings take place externally. Less commonly, an opening is formed through the posterior wall of the meatus; in rare cases the pus breaks through the process on its internal aspect. Very serious complications are developed when the wall of the sigmoid sinus or the roof of the mastoid antrum gives way.

Caries and Necrosis of the Mastoid Process as a result of inflammation of the mastoid cells are most common in children. The two processes are often united, the cellular tissue of the bone being the seat of caries, while the compact substance becomes necrotic. The frequency of carious and necrotic processes within the mastoid portion is largely due to its structure, which facilitates the retention of infective matters and their action upon the periosteum and bone. The formation of abscesses and fistulous openings has been already alluded to. In tuberculous children, as a result of periostitis, patches on the surface of the mastoid process are apt to become carious, without participation of the deeper portions.

It is remarkable that caries and necrosis of the mastoid process may go on for some time, and result in considerable destruction, without causing any marked subjective or objective symptoms.* Instances of this kind are not infrequent in tuberculous subjects. There is, however, usually more or less pain or uneasiness in the part and tenderness on pressure, and the periosteum is apt to become swollen and inflamed. The temperature is usually raised, and the discharge from the meatus is dark-coloured, more or less profuse and fœtid. Little, if any, improvement results from antiseptic remedies. The posterior wall of the deep part of the meatus is often reddened and swollen. In advanced cases, there may be signs of facial paralysis and of intracranial complications. If an incision be made, the finger or probe will often detect dead bone or fistulous openings. The latter are apt to be occluded by granulation tissue, which is sometimes so abundant as to cause a sensation of fluctuation before the skin has been perforated or the parts laid bare by an incision. In young children suffering from tympanic inflammation, the formation of fistulous openings in the mastoid is favoured by imperfect ossification, and especially by the masto-squamous fissure, the remains of which, in the form of minute depressions and openings, are often visible in the adult bone.

---

* See a report, by Dr. H. Ferrer, of a case in which external symptoms were absent, *Archives of Otology*, vol. xvii. p. 314.

It sometimes happens that the pus of an abscess in the mastoid process finds its way to the surface through the posterior wall of the external meatus. In such a case, the discharge is preceded by inflammation of the periosteum and bulging of the wall of the meatus, perhaps to such an extent as completely to occlude the passage. After discharge of the pus, a fistulous opening remains, more or less covered up by sprouting granulation tissue.

In those cases in which the disease of the bones is due to extension of suppurative inflammation from the tympanum, perforation of the membrane is almost invariably present. The membrane has, however, been found normal in such cases.

The **Course** of the morbid process when the bone is affected varies in different cases. Extension of the inflammation in an outward direction, with periostitis and abscess as results, is the most common course. Several such abscesses, in more or less rapid succession, over the mastoid process are indicative of disease of the bone. Sometimes the pus finds its way down the side of the neck and forms a swelling of considerable size; it may pass forwards to the side of the pharynx and downwards even as far as the pleura. Abscesses of this kind are prone to occur when there is caries of the mastoid cells, while the cortical portion of the bone has become thickened and indurated. The inflammation may likewise extend towards the cranial cavity, and set up phlebitis of the sigmoid sinus, or involve the Fallopian aqueduct and the membranes of the brain. This latter result is not infrequent in children; in adults the cerebellum is most often affected. In favourable cases the carious and necrotic portions are detached, the granulation tissue is absorbed, and healing takes place (see Fig. 121). Sometimes a good result is obtained after exfoliation of the whole of the mastoid process. On the other hand, only small portions of bone may be detached, and fistulous openings may remain for some years, or until properly dealt with. These openings sometimes become closed for a time and then open again, and yield more or less copious discharge. Polypoid growths are apt to form in cavities left after the discharge of an abscess, and may assume a large size.

The **Prognosis** in cases of mastoid disease varies with the cause, extent, and severity of the affection, and with the general health of the patient. It is favourable when the lesion is not deeply seated, and when all secretions can escape from the meatus, and the patient exhibits no signs of any marked dyscrasia. It is unfavourable in tuberculous cases, and when there is extensive and deep-seated caries and pent-up secretions, with intermittent febrile attacks, when the cortical layer is indurated and thickened, and when the tympanum is the seat of severe and chronic changes. The prognosis is always serious whenever there are symptoms of extension of the inflammation to the membranes of the brain. Attacks of partial or complete unconsciousness, restlessness, and feverishness are always of grave import when occurring in a person suffering from disease of the mastoid process.

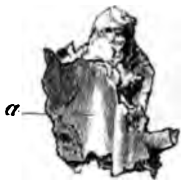


FIG. 121.

Natural Size.

A SEQUESTRUM FROM THE MASTOID PROCESS, with a portion of the groove (*a*) for the sigmoid sinus. It was removed by the author from a child, aged five years, who was brought to the London Hospital on account of a purulent discharge from the right ear following scarlet fever.

Treatment.—In treating a case of inflammation of the mastoid cells, the cause of the mischief is the first point to be ascertained. If, as often happens, there be chronic suppurative inflammation of the tympanum, it is best to open up at once the mastoid process, mastoid antrum, attic, and tympanum; but when the membrane is intact and there is no evidence of the tympanum being involved, only the mastoid process need be exposed.

The Operative Treatment of Acute Inflammation of the Mastoid Cells, the result of acute middle-ear suppuration, differs in many important respects from the measures requisite for the cure of chronic processes. In the former, the most common site of the abscess is the middle and lower part of the vertical portion of the mastoid process, lying next to the cortical layer. As a rule, there is only one abscess cavity, and this is almost invariably isolated. The operation is therefore simple, easily performed, and generally successful. In the chronic cases, on the other hand, not only the mastoid antrum has to be opened, but it is usually necessary to establish free communication between it and the attic, the tympanum, and the external meatus, to such an extent that all these parts are converted into one cavity.

Opening the Mastoid Process in Acute Suppuration. —As this operation is not so frequently required and is comparatively simple, the details as regards the preparation and position of the patient and other steps will be reserved for the description of the operation for opening the mastoid antrum and tympanum. The incision should be made as in that operation, but it need not be carried so far forward. The special instruments required are a raspatory, several chisels and curettes, a mallet, bone-forceps, and electric head-lamp.

The incision having been made, the periosteum is pushed away with the raspatory from the line of incision on both sides, until an area of about three-quarters of an inch of the middle portion of the mastoid surface is laid bare. Hæmorrhage is checked by compression, ligature, or pressure with gauze, as required. The next step is to chisel out a piece of the cortex, about two-fifths of an inch wide and three-fifths of an inch vertically. The abscess is frequently reached after the first blow of the mallet; but it may be necessary to enlarge the opening in various directions. When the abscess-cavity has been exposed, all diseased tissue must be freely but carefully removed with the chisel or a curette. If the abscess has existed for some time, it may be necessary to remove a large portion of the mastoid process, even to such an extent as to expose the sigmoid sinus.

The application of iodoform gauze is usually sufficient to check the hæmorrhage, if the sinus is injured or intentionally opened.

After it has been well scraped, the abscess-cavity is irrigated with perchloride of mercury solution (1 in 2,000), and lightly packed with iodoform gauze. To diminish the size of the wound, several small sutures are placed in the skin, the number depending upon the size of the opening in the bone. When the opening is but small and superficial, and all morbid secretion and tissue have been removed, the wound, after lightly dusting with iodoform, may be closed immediately after the operation.

With deeper cavities in the bone, and the possibility that some infectious materials may still remain, it will be better to place a suture at the upper and lower angle, and to pack the cavity with iodoform gauze. In the absence of severe pain and of profuse secretion, the gauze may be retained for from three to six days. If the cavity is large, it should be lined subsequently with epithelium.

Opening the Mastoid Process in Chronic Suppuration.—It will be necessary to discuss at some length the operative treatment of chronic suppurative diseases of the mastoid process, as they are always associated with, and usually result from, a similar condition in the tympanum. Considerable experience is requisite to enable the surgeon to decide as to the actual presence of purulent inflammation of the mastoid cells. Severe uncontrollable pain is generally regarded as a special indication; but, as a matter of fact, this symptom is by no means pathognomonic of the condition in question. It may indeed be due to inflammation strictly limited to the periosteum. Fever may or may not be present; its absence does not indicate that the mastoid cells are free from disease. In common with pain and tenderness, fever becomes a prominent symptom when the periosteum is affected. A more trustworthy indication is to be found in the presence of inflammatory swelling of the meatus, involving especially the posterior superior wall of the osseous portion, and a similar appearance below the apex of the process. Pus may break through into the meatus by one or more openings, from which granulations are apt to sprout, so as to block up the passage. Swelling of this character, involving the posterior superior wall of the osseous meatus, should be distinguished from a similar condition of the roof of the meatus, close to the tympanic membrane, and due to extension of inflammation from the upper tympanic spaces, although the operative treatment is similar in both cases. Ordinary furuncular inflammation may cause somewhat similar appearances; but the history of the case will suffice to distinguish it from suppuration of the mastoid cells.

In cases of middle-ear suppuration, with no external symptoms referable to the mastoid process, the setting-in of pain and fever, accompanied by the sudden cessation of discharge, especially if it has previously been copious, indicates retention of secretion, which is liable to cause dangerous complications. If the symptoms be not relieved by ordinary measures (*e.g.*, syringing by the meatus and injections through the Eustachian tube), opening of the mastoid antrum should be undertaken without delay. The operation is even more decidedly indicated when the presence of cholesteatomatous masses in the middle ear is associated with symptoms of cerebral irritation, *e.g.*, unilateral headache, giddiness, vomiting, and changes in the pupil and fundus. In such cases palliative measures are always useless, and are certain to prove mischievous, inasmuch as they cause the postponement of the operation, which alone is likely to be attended with good results.

In a case of purulent otitis media, the earliest appearances of pathological hyperæmia of the optic papilla in an eye previously normal, must give rise to the suspicion of intracranial complications, and would be an additional indication for opening the mastoid process. The absence of any other cause which would account for the hyperæmia in the fundus oculi must, of course, be determined. If there be decided optic neuritis, which may be the earliest sign of an intracranial complication, the operation is still indicated, though probably too late to be of any service. If the eye-symptoms continue unchanged after the operation, the prognosis is very unfavourable. The appearances in the eye are due to inflammatory increase of the sub-arachnoid fluid, and its mechanical accumulation in the sheath of the optic nerve, close to the eyeball. It is possible that the lymph-canals around the central vessels may be irritated and plugged up by micro-organisms, but the extent to which the symptoms are due to this cause has not been clearly ascertained. Delirium, vertigo, difference in the size of the pupils, double vision from paralysis of the ocular muscles, sopor, and even unilateral motor paralysis of the extremities, may prove to be transient, and do not prevent the success of the operation.

The statement that the operation is sometimes indicated as a prophylactic measure, *i.e.*, in order to prevent the dangerous complications of middle-ear suppuration, is necessarily comprehensive and indefinite. The number of cases in which an operation appears to be indicated will vary according to the experience and proclivities of different surgeons. It is undoubtedly true that many cases, which have proved intractable to ordinary treatment, can be cured by opening the mastoid antrum and tympanum, and removing the carious ossicles and the results of the chronic inflammatory processes. The long continuance of a discharge must not be considered a sufficient reason for immediately opening the mastoid process, inasmuch as an otorrhœa which has existed for many years may be cured by appropriate treatment. The author has had two cases in which the discharge had persisted for forty-seven and fifty years respectively, and which were cured in about six weeks by treatment with antiseptic lotions and insufflations of boric acid. When the discharge continues in spite of treatment, or recurs from time to time, the mastoid process and tympanum should be opened, as such conditions indicate caries or necrosis, or a collection of cholesteatomatous material or inspissated pus in the middle ear.

When the cortex of the mastoid process is decidedly indurated, there may be no external signs of disease, even in cases in which suppuration has existed therein for several years, and where carious excavations and sequestra are present. In another class of cases, with similar external conditions, the bone is to a large extent solid and almost or quite devoid of pneumatic spaces; the antrum is indicated by a minute quantity of caseous pus or of cholesteatoma. Considering this diversity of pathological changes, it is obvious that careful and prolonged examination is the only means whereby a decision can be arrived at with regard to the operation. The following changes may be regarded as indicative of mastoid disease: inflammatory swelling of the meatus, involving especially the posterior superior wall of the osseous portion; an inflammatory swelling below the apex of the mastoid process; a fistulous opening in the osseous meatus; a perforation in the posterior and upper part of the margin of the tympanic membrane; a large carious opening, through which a suitably bent probe may be passed into the mastoid process. In such cases, there may be considerable destruction of bone; but no marked symptoms arise until the pathological process affects the semicircular canals or the meninges on the one hand, or the periosteum on the other.

When the diagnosis has been made, the operation should be performed as soon as possible. Dangerous complications may at any time supervene, and without any premonitory symptoms. The prevention of such risks is the object of the operation.

The conditions revealed on opening the mastoid process vary considerably in different cases. They may be described under at least three headings.

1. The abscess-cavity comes into view at once. There may be but little change of structure; but the cells are filled with purulent secretion of varying consistence. The lining membrane is hyperæmic, but not decidedly thickened, and the osseous framework of the cells is comparatively normal. At a later stage, there will be found, mingled with the pus, fragments of dead bone or one large sequestrum, either movable or attached to the walls of the abscess. Granulation-tissue and polypoid formations are also present.

2. The process is found to be hard, like ivory (sclerosing mastoiditis). The cells are greatly diminished in size, and many of them totally obliterated; perhaps only the antrum can be distinguished with some difficulty. The bone is abnormally dry; but many of its blood-vessels are still preserved. This condition is ordinarily the result of long-continued middle-ear suppuration. The cortex of the mastoid process is at the same time indurated and thickened (hyperostosis), and the walls of the tympanum are often found in a similar condition.

3. The mastoid process, and especially the antrum, are frequently occupied by cholesteatomatous formations. These appear as shining white masses, made up of concentric layers; their continuous growth causes atrophy of the walls of the cavities in which they are contained. They may fill up the entire series of cells, and may break through the posterior wall of the meatus and even the roof of the tympanum, and the osseous wall of the groove for the sigmoid sinus.

In less common cases of mastoid disease, two other conditions, differing from those already described, sometimes present themselves. On removing the outer layer, the cancellated tissue is but little, if at all, changed. The cells are filled with red swollen masses, consisting of the hyperæmic and infiltrated lining membrane. The bone is softened and easily cut with the chisel. Hæmorrhage is likely to be profuse, and is checked with difficulty. In another form, an opposite condition is revealed. The cancellated tissue is yellowish white, hard, and dry; the pneumatic cells are occupied by pale gelatinous masses. The condition is apparently that of œdema, and the larger spaces contain more or less mucus. The operation is attended with but slight hæmorrhage.

The anatomical relations of the mastoid process are such as to render great care necessary in performing the operation. The internal surface is in close contact with the sigmoid sinus and with the floor of the posterior fossa of the base of the skull. The spot at which the sinus is nearest to the surface is situated about three-fifths of an inch behind the suprameatal spine. The position of the mastoid antrum is best indicated by drawing a horizontal line along the upper border of the meatus, and a vertical line one-eighth of an inch behind the posterior border; a point slightly above the meeting-point of these two lines will indicate the position of the antrum. In adults, this point will be found to be about an eighth of an inch behind and slightly above the suprameatal spine. The usual distance between the posterior wall of the meatus and the antrum is about one-twelfth of an inch. The external semi-circular canal, which is above and behind the facial canal, causes the external wall of the antrum to bulge out. In 66 per cent. of the skulls examined by Dr. Hartmann, the floor of the middle fossa of the base was above the linea temporalis, at a distance of two-fifths of an inch behind the external meatus. A similar investigation, undertaken by Dr. Schülzke, yielded a proportion of 82·5 per cent.

The indications for opening the mastoid process and tympanum may be summarised as follows:—

1. In acute inflammation of the mastoid process occurring in a patient who is suffering, or has previously suffered, from suppurative inflammation of the middle ear.

2. In chronic inflammation of the mastoid process, attended

with recurrent swelling of the part, or with the formation of abscesses or cutaneous fistulæ, even in the absence of any obvious symptoms of a directly threatening character.

3. In chronic suppuration of the middle ear, without external signs of inflammation of the mastoid process, after a fair trial has been made to stop the discharge by the application of remedies through the meatus.

4. Whenever symptoms occur, suggestive of the advent of dangerous complications resulting from retention of secretion or the formation of cholesteatoma.

The objects aimed at in the operation about to be described are: the complete removal of morbid materials from the middle ear and the cavities communicating therewith; the free exposure of these spaces and the establishment of unobstructed communication between them; finally, the arrest of the discharge from the granulating surfaces and the protection of the cavity which has been formed, by lining it with epithelium.

Opening the Mastoid Process, Antrum, Attic, and Tympanum. Preparation of Patient.—The side of the head should be shaved, the hair being removed from an area at least two inches in width beyond the bare skin underlying the auricle. The scalp should then be thoroughly washed with soap and water; afterwards ether should be applied, and lastly it should be swabbed with a solution of biniodide of mercury (1 in 2,000). The auditory meatus also should be washed out with a warm solution of biniodide of mercury of the same strength. A compress of lint soaked either in perchloride or in biniodide of mercury solution (1 in 2,000), should then be applied over the auricle and adjacent surfaces of the scalp and face; the former lotion is perhaps preferable, since the latter is liable to blister a sensitive skin. If time permit, a second compress may be applied after the lapse of a few hours. The patient should be prepared for the anæsthetic in the usual way. No food should be taken by the mouth for at least five hours before the operation, the last being some strong beef tea. In the majority of cases it is advisable to administer a mild purgative on the previous evening.

Instruments.—The following instruments should be at hand:—Scalpels and blunt-pointed straight bistoury; two pairs of dissecting forceps; a pair of bent aural forceps; retractor with sharp-pointed ends; one pair of large scissors; one pair of small curved strabismus scissors; a dozen pairs of artery forceps; raspatory; curved needle in handle; two blunt dissectors; two chisels, 5mm. and 2½—3mm. in width respectively; gouge, cut square at the end; mallet; Macewen's searcher; slender flexible probe; sharp spoons; several probes to be used as cotton-wool holders; needle holder; curved and straight needles; 3-oz. glass syringe, sterilised; drainage tube; ribbon iodoform gauze; electric head-lamp and battery. In those cases in which complications may be anticipated, the operator should provide himself with trephines; Hoffman's forceps; dura mater separator; antiseptic wax; and other instruments necessary for the removal of a portion of the skull cap.

Additional Instruments required for Skin-Grafting Operation:—A large Thiersch razor; two spatulæ or lifters; moulder for pressing in gold foil; two needles for holding graft (one bent at the end); gold leaf (16,000th of an inch); glass pipette with india-rubber tube and mouthpiece attached; a mixture of glycerine (one part) and alcohol (90 per cent., ten parts) for lubricating the razor and skin. In addition to the instruments specially required for the second operation, it is advisable to take all of those which are used at the first operation; for sometimes, on examining the cavity, more diseased bone is found which requires to be removed.

Position of Patient.—The patient should lie on the sound side, with a sandbag or firm pillow placed beneath the neck and head. A sterilised towel should be fastened round the head so as to cover the hair. If there is no top-light, the table should be placed obliquely, so that the light falls from a window on to the upper and back part of the head. In this position the surgeon does not stand in his own light. The anæsthetist should stand opposite the surgeon, facing the patient; while the assistant is most conveniently placed at the head of the table. By this arrangement the light falls on the patient's head between the surgeon and his assistant.

The Operation.—In operating on the right ear, the incision should be commenced half an inch behind the anterior attachment of the helix, and half an inch above the attachment of the auricle; in passing backwards and downwards, the incision should recede to a distance of three-quarters of an inch from the attachment of the auricle, or even more in those cases in which there are symptoms of involvement of the mastoid cells, and should extend downwards nearly as far as the most prominent portion of the mastoid process, and a little below the level of the base line. In operating on young infants, care should be taken not to carry the incision below the level of the floor of the meatus, as the stylo-mastoid foramen in early life, owing to the undeveloped condition of the mastoid process, opens externally on the outer surface of the skull, and the facial nerve may therefore be divided if the incision be carried too low. The incision should extend at once through all the structures down to the bone; but in the case of young children, care should be taken not to press too heavily, as the osseous structures are often exceedingly soft and crumbling. In operating on the left ear the incision is more conveniently commenced below, over the mastoid process, and carried forwards to the point indicated. While the incision is being made, the assistant should press with his thumb in the depression below the lobule and in front of the mastoid process, in order to close the posterior auricular artery; and with his index finger in front of the tragus, should compress the temporal artery. This procedure, besides checking the bleeding, permits the operator to get a better view of the parts. The pericranium, having been slightly detached with a scalpel, is then peeled forward with a raspatory, until the posterior and the upper margins of the osseous meatus are exposed. The membranous meatus is conveniently detached from the superior, posterior, and inferior walls by means of a blunt dissector; but its connection with the anterior wall should not be disturbed. A piece of No. 4 silk is now carried by means of an aneurysm needle through the meatus, and brought out of the wound posteriorly; the two ends are knotted, and the auricle is pulled forward by an assistant, or it may be held in that position by a weight attached to the silk.

The mastoid antrum, which is the first objective of the operation, lies in the suprameatal triangle of Macewen, already described (see page 66). It is situated immediately beneath a point an eighth-of-an-inch above and behind the suprameatal spine, which is almost invariably present in adults, and lies at the junction of the superior and posterior margins of the osseous meatus. In young children and infants, its position is sufficiently defined by taking a point occupying the same relative position to the junction of the superior and posterior margins of the meatus. It should be remembered that the mastoid antrum almost invariably lies slightly above the level of the superior margin of the osseous meatus, and this fact is even more pronounced in children than adults. For exposing the mastoid antrum, the safest instrument is a chisel or gouge. It has been stated that the vibrations caused by hammering the chisel produce concussion of the brain ; but the author, having had the experience of a large number of cases operated on in this manner, and never having met with such a result, can confidently assert that such symptoms must be rare, especially as the experience of other surgeons, to whom he has referred with respect to this matter, coincides with his own. Some surgeons use a drill driven by an electro-motor, but, in the opinion of the author, accidents are liable to result from the employment of this instrument unless great care be exercised. A triangular surface of bone above and behind the suprameatal spine, having its apex directed upwards and backwards, must next be cut away, together with the whole of the upper margin and the upper two-thirds of the posterior margin of the meatus. In directing the chisel, the obliquity of the bony meatus should be kept in view. An abnormal position of the sigmoid sinus may render it extremely difficult to reach the antrum in the ordinary way from the surface. Under such circumstances, the antrum can best be exposed by removing the deeper part of the posterior wall of the external meatus. If the antrum be not found in its usual position, it should be sought for on a higher level. In those cases in which it is proposed to erase the walls of the tympanum and remove the membrane and ossicles, much assistance is derived in locating the mastoid antrum by passing a Macewen's searcher or bent probe along the junction of the posterior and upper walls of the meatus into the aditus ad antrum. Care must be taken not to pass the instrument into the recess of the Fallopian aqueduct, as by so doing in some cases the facial nerve may be injured. Some operators insert a Stacke's protector into the aditus, and cut down upon it. In acute cases, in which it is inadvisable to disturb the membrane, these procedures should not be resorted to. It must not be forgotten that the external semicircular canal, which is above and behind the facial canal, causes the internal wall of the antrum to bulge into the cavity. After opening the mastoid antrum, the narrow bony bridge which separates it anteriorly from the tympanum and overlies the aditus must be carefully cut through with a fine chisel. The position of this passage must be carefully made out with a Macewen's searcher, and it must be remembered that the facial nerve runs internal to and beneath its inner and inferior walls, respectively.

In the next stage, the attic is exposed by taking away its external wall, the pars ossea of the external wall of the tympanum. This is the most internal portion of the upper wall of the meatus, which here forms part of the floor of the upper tympanic space or attic. The free border of this osseous plate serves for the attachment of the upper margin of the tympanic membrane. It must be removed to such an extent that no projection between the roof of the tympanum and the upper wall of the meatus can be felt with the probe. The removal is effected with a chisel; and while this is being done, the incus and malleus (if present) will come into view and may be removed with the forceps. Any remains of the tympanic membrane may likewise be removed.

The next step is to expose the lower tympanic space, the osseous floor of the tympanum, which is below the level of the inferior wall of the meatus. The outer boundary of this space is formed by the free end of the lower osseous wall of the meatus, which in adults is somewhat thick and prominent. By using a bent probe, the form and extent of the recess can be made out; it is generally most developed posteriorly. The free internal edge of the floor of the meatus, to which the lower border of the tympanic membrane had been attached, is then removed, layer by layer, with a flat chisel, until no projecting part between the meatus and the floor of the tympanum can be detected with the probe, and the floor of the tympanum becomes quite visible. It must be remembered that beneath this part is the commencement of the jugular vein, and that the bone sometimes presents gaps, through which the vein may project into the tympanum. It must also be remembered that the descending portion of the facial nerve passes close to the posterior part of the osseous floor of the tympanum, and part of the posterior wall of the meatus must be left in order to prevent injury to the Fallopian aqueduct. This portion finally projects as a ridge into the cavity formed by the operation. Whilst chiseling or curetting in this region, careful watch must be kept for any twitchings of the muscles supplied by the nerve.

Finally, as a precautionary measure, the mastoid cells should be exposed by removing the outer compact wall of the process, and any patches of septic granulation tissue extending from the floor of the antrum into the mastoid cells should be carefully followed up. Whilst chiseling in the neighbourhood of the posterior and inferior walls of the antrum, the proximity of the sigmoid sinus should be borne in mind. In some cases it will be necessary completely to cut out the whole of the mastoid cells. Before the chisel is laid aside, search should be made for any fistulous openings leading into the middle or posterior fossa of the base of the skull; and it must be ascertained, by passing a bent probe along the walls of the cavity which has been made, that overhanging edges nowhere exist. This precaution is especially necessary in the case of the attic, and upper wall of the antrum; and it often happens that the tegmen tympani or tegmen antri must in part be removed, the dura mater being exposed, before the walls are rendered completely level. Every doubtful spot having been chiseled or scraped, all granulation tissue and cholesteatomatous material is then carefully taken away with a sharp spoon, the malleus and incus should be looked for and removed with the bent ear-forceps, if they have not been previously extracted, and any remains of membrane taken away either by scraping with a sharp spoon, or, if necessary, by cutting with scissors. In clearing the posterior wall of the tympanum and the recess in front of the Fallopian aqueduct, the patient's eye should be carefully watched, since it occasionally happens that at this point the facial nerve is exposed, owing to the destruction of the osseous walls of its canal. The operation having been completed, the cavity and the membranous meatus should be washed out with a solution of biniodide of mercury (1 in 2,000).

Formation of a Flap to partially line the Cavity.—Various methods have been employed for utilising the posterior and upper wall of the membranous meatus, in order to form a flap to assist in filling up the cavity left by the exposure of the mastoid antrum. With this object, two parallel incisions are made by passing a bistoury through the meatus and cutting in a direction upwards and backwards, the upper one from the junction of the posterior and superior margins of the membranous meatus, the other from the lower part of the posterior margin. The incisions should be continued through the meatus for a distance of about one-third of an inch into the auricle, and the flap between the incisions pressed back into the antrum by means of a plug of gauze.

In those cases in which it is intended to cover the whole of the cavity with skin-grafts, after the manner suggested by Mr. Ballance, it is advisable to form a flap from the membranous meatus and adjoining portion of the concha in the following manner:—An incision is made through the whole length of the inferior wall of the meatus into the concha with a blunt-pointed, straight bistoury, introduced from without through the membranous meatus. It is then curved backwards and upwards at a distance of about one-third of an inch from the posterior margin of the membranous meatus; and just above the level of the upper wall of the meatus, it is carried forwards, and finally enters the meatus again about the centre of its upper wall. Whilst making this incision a vessel is usually divided, which, if not secured, is liable to soil the dressings subsequently. The flap thus made should be raised in a direction upwards and inwards, and fixed against the back of the auricle by means of silkworm gut sutures, which are carried through its edge and then through the skin of the mastoid flap

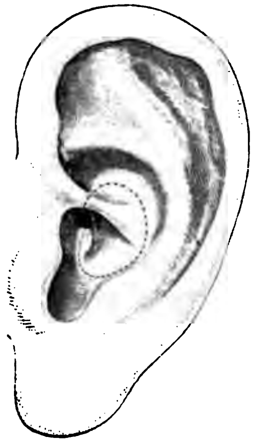


FIG. 122.

DIAGRAM SHOWING THE LINE OF THE INCISION FOR MAKING THE FLAP.

at a position above and behind the auricle. Two sutures may be used, their ends being knotted over portions of drainage tube laid upon the skin of the mastoid flap. Before fixing the flap, any ragged edges of cartilage which project should be snipped off. The cavity is then carefully packed with ribbon iodoform gauze (which may be obtained from the Galen Manufacturing Company), and the end brought out through the auricle. Unless special precautions are taken, the auricle will slip to a much lower level than its normal position. In order to prevent this, it is well to remove a slice from the upper border of the flap, and then pass some stout sutures through the flap, and fasten them over drainage tubing to the skin above the line of the incision. The edges of the first incision are then united with silkworm gut sutures.

Description of the Second or Grafting Operation.—For this ingenious addition to the resources of the surgeon, the profession is indebted to Mr. Charles A. Ballance.* A day or two before the operation the plug of gauze is removed, and the ear syringed out night and morning with carbolic acid solution (1 in 40). During the operation, the only fluid used should be a half per cent. salt solution made with boiled water. The anæsthetic having been administered, and the patient placed in the same position as for the first operation, the incision is opened with the handle of a scalpel, and the mastoid flap with the auricle turned forward. The cavity is then irrigated with salt solution, and if any suspicious patches are observed, they should be scraped or chiseled. The whole of the freshly-cut osseous surfaces are found to be covered with delicate pink granulations, which bleed readily, and must therefore be sponged very gently. If any bleeding occur from the edges of the incision, it may be arrested by the application of hot water. The skin-graft is most conveniently taken from the anterior and inner surface of the thigh, the skin having been previously sterilised in the usual manner. In order to obtain a flat surface for cutting the graft, the assistant flattens the surface of the thigh by holding against it, just above the point from which the graft is to be cut, an ordinary paper-knife or an instrument having a long, even surface. The skin is then moistened with the mixture of glycerine and spirit, in which the razor is also dipped. The surgeon, grasping the thigh with his left hand in such a way as to flatten it and put the skin on the stretch, then applies the razor, and with very rapid sawing movements cuts the thinnest possible graft. If sufficiently large to line the whole of the osseous cavity, it should measure not less than 6cm. in length by 5cm. in breadth. From the razor the graft is transferred to the spatula. The cavity is again carefully dried with cotton-wool on probes, or with small pieces of gauze, and the auricle is well drawn forward by means of a sharp retractor or a thread passed through the meatus. The edge of the spatula carrying the graft is applied along the anterior margin of the bony cavity. The graft is fixed in this position at the upper and lower ends respectively of the anterior margin by two probes or needles held by the assistant. The operator then gradually withdraws his spatula, at the same time that he insinuates the graft into the deeper recesses of the cavity with a blunt-ended probe or moulder already mentioned. Any fluid or air which has collected beneath the graft should be withdrawn by the pipette. The graft should be manipulated until it covers and lies flat against the following parts:—(1) The anterior wall of the cavity, formed internally by the anterior boundary of the tympanum and attic, and externally by the anterior wall of the enlarged osseous meatus. (2) The anterior part of the roof of the cavity, formed by the tegmen tympani and the superior wall of the enlarged osseous meatus. (3) The tegmen antri. (4) The inner walls of the attic, tympanum, and antrum, and the ridge formed by the Fallopian aqueduct; and (5) The floor of the tympanum and antrum.

---

* *Med.-Chir. Trans.*, 1900.

It is usually advisable to cover the posterior wall of the mastoid antrum; but if a large cavity has been left in the mastoid process by the chiseling away of its cells, Mr. Ballance suggests that this may remain uncovered by the graft, as adhesion will readily take place between the osseous surface and the inner surface of the cutaneous flap. The author's experience, however, leads him to think that it is better to line even a large cavity with epithelium, rather than risk the formation of septic granulation tissue in the lower part of the cavity. The graft having been carefully adjusted, a piece of gold foil, of about the same extent, is then applied to its surface with the moulder. Its concavity is filled with ribbon gauze, which is firmly pressed into position. By this manipulation, any *fluid* which may have accumulated beneath the flap is squeezed out. The end of the strip of gauze having been brought through the meatus, the portion of the inner surface of the mastoid flap lying opposite to the antral cavity, which, when in position, forms its outer wall, is covered with a skin-graft. It is advantageous to carry this graft forward, so as to cover the raw surface from which the flap has been taken, corresponding in position to the posterior wall of the enlarged meatus, as from this point exuberant granulations are prone to form during the healing process. This graft is likewise overlaid with gold foil.

Should the operator fail to cut a graft sufficiently large to cover the whole cavity, he must adapt a second graft along the edge of the first one. The operation is completed by replacing the mastoid flap and closing the wound with sutures. During the next few days, the external dressing may be changed twice. On the fifth or sixth day, a thigh having been again sterilised, the patient should be anæsthetised, and the flap turned forward as before, so as to allow the cavity to be carefully inspected after the gauze and gold foil have been removed. If places are found which have not been covered with skin and from which granulations are springing, they should be scraped and covered with a graft and gold foil as at the previous operation. The procedure only postpones the final closure of the wound for a few days, but it may prevent a discharge occurring which would last for several months and eventually necessitate the wound being again reopened so as to remove the granulations and cover them with skin in order to stop the discharge.

Exfoliation of the epidermic layer usually takes place and may cause anxiety as to the vitality of the graft, if this occurrence is not anticipated. Slight discharge not infrequently continues from some exuberant granulations, and it may be necessary to destroy these either with a probe tipped with nitrate of silver, or with a saturated solution of chromic acid. In such cases it is advisable to syringe the cavity daily with rectified spirit.

It is necessary to remove the gold leaf not later than the end of a week; for if it be allowed to remain, secretions are apt to collect behind it, especially that portion which is in contact with the inner surface of the skin-flap. As these secretions are not thoroughly removed by syringing, the discharge is liable to be kept up by the irritation thus produced. The ultimate result is almost always satisfactory, provided that the osseous tissue infiltrated with septic granulations has been sufficiently removed at the first operation.

The accidents and complications which may occur during the operation are mainly due to injury of parts in close relation to the mastoid antrum. They are as follows:—(1) Venous hæmorrhage from large veins in the bone, or as a result of injury to the sigmoid sinus; (2) Injury to the facial nerve; (3) Injury to the labyrinth; (4) Injury to the dura mater or to the brain, the floor of the middle fossa of the base of the skull having been perforated by the chisel.

Injury to the sinus may cause a considerable amount of hæmorrhage, which, however, can be checked by laying a plug of gauze over the aperture, and allowing it to remain there for two or three days. To avoid the sigmoid sinus, the opening through the bone should be cut inwards and forwards, parallel to the posterior wall of the meatus.

Injury to the facial nerve may occur whilst the bony covering of the Fallopian aqueduct or the recess in front of it is being chiseled. Whilst this is being done, the patient's face should be carefully watched, and the slightest twitching should warn the operator that the chisel or other instrument has injured the facial nerve. If contusion or partial division, as shown by paresis, be caused by the injury, the prognosis is usually favourable. In such cases the levators of the angle of the mouth are affected relatively more than the orbicularis oculi. The symptom generally passes off, though it may last for several months. Paresis or paralysis coming on a few days after the operation is due to effusion within the canal, and usually subsides.

Injury to the labyrinth is always a serious occurrence. The horizontal semicircular canal bulges out into the inner wall of the antrum, and may be reached by the chisel at a depth usually exceeding half an inch from the surface. If an opening be made, infectious matters may pass inwards from the wound, and set up purulent inflammation of the labyrinth, with meningitis as a result. Apart from this last very dangerous complication, the hearing-power will probably be destroyed. Disorders of equilibrium and tinnitus will also be experienced; but these symptoms will probably subside.

Exposure of the dura mater is not of importance, unless the membrane or the brain be at the same time injured. Removal of diseased bone frequently necessitates exposure of the membrane. Care must be taken to prevent infectious materials from passing beneath it; and any splinters of bone, if loose, must be cautiously removed. Probing or irrigation must be done very gently, and when the dressings are changed, care should be taken not to injure the granulations which will spring up from the dura mater.

Results and Prognosis of the Operation.—Since the introduction, by Mr. Ballance, of the method of grafting the cavity with epidermis, the results of the operation have been far more satisfactory. Formerly, the discharge from the granulating surfaces continued for two or more months, and in some cases did not entirely cease, necessitating the cavity's being reopened and curetted, so as to obtain a more healthy growth of granulation tissue. In other cases, the discharge ceased for two years or more and then recurred. After the application of the skin-graft in the method now employed, some discharge may continue for a few weeks from the granulations which form around the edges of the grafts, generally at the upper and posterior wall of the meatus, and the outer wall of the cavity formed by the operation, the latter surface consisting of the inner side of the skin-flap. If these granulations are kept down, the epidermis spreads over them in the course of a few weeks, and forms a non-secreting surface. Persistence of discharge from any given spot may be caused by a piece of diseased bone which has been overlooked, or by a piece of bone which has not become covered with healthy granulations, or by the reproduction of septic granulations. A careful examination should be made for any one or all of these, with a view to removal. The scar behind the ear, being covered to a greater or less extent by the pinna and by the hair, is hardly seen, and the enlargement of the meatus by the removal of the flap from the concha is not noticeable.

In cases of chronic suppurative inflammation of the middle ear without acute symptoms, patients are especially anxious to know what effect the proposed operation for the arrest of the discharge is likely to have on their hearing; and frequently state that they prefer to run the risk of complications arising from the existing state of the ear to that of becoming permanently deaf. Although it is impossible to foretell the precise condition which will be found when the middle ear is opened, and therefore the limits of the steps which may be found necessary to remove entirely all diseased tissue, it is obvious that a more favourable prognosis may be given when the symptoms are of comparatively short duration and do not point to the implication of the labyrinth, than when the opposite conditions exist. In estimating the amount of mischief which is likely to be found, too much importance must not be attached to the absence of acute symptoms; for they may have been absent for years, and the discharge may even have ceased during the corresponding period, and yet extensive and old-standing mischief may be found when acute symptoms, or a recurrence and persistence of the discharge, have rendered an operation desirable. After the operation, the hearing-power usually returns to about the same degree that it was previously; sometimes it is better, but at other times it is worse. No improvement can be expected when the labyrinth is seriously affected. When the operation is undertaken for chronic caries or necrosis, the prognosis depends upon the extent to which the bone is involved. If the mastoid process alone be affected, the prognosis is more favourable than when the walls of the tympanum, the ossicles, or portions of the osseous labyrinth are likewise diseased. Even under apparently favourable conditions, it is impossible to affirm that, as a result of the operation, the hearing will not be impaired. But nevertheless, considering the grave risks that are run by allowing the chronic suppurative changes to continue, especially when acute attacks from time to time occur, the possibility of increased deafness ought not to be considered a sufficient reason for allowing the mischief to remain, especially when only one ear is affected. Sufficient time has not yet elapsed to enable a definite comparison to be formed, as regards the maintenance of hearing-power, between the results of the operation before and after the introduction of skin-grafting; but from the results already obtained, it appears that the new method will compare advantageously with the old one.

CHAPTER XXXIV.

CRANIAL AND OTHER COMPLICATIONS OF MIDDLE-EAR SUPPURATION.

Extension of Morbid Processes to Intracranial Structures—Number of Cases due to Middle-Ear Suppuration—Relative Frequency of the various Intracranial Complications—Anatomical Conditions facilitating Extension of Morbid Processes from the Tympanum—Causes of the Intracranial Lesions—Micro-organisms—Cerebral Meningitis—Various Forms, Pachymeningitis and Leptomeningitis—Morbid Anatomy—Extradural and Subdural Abscesses—Symptoms—Diagnosis—Treatment—Cerebral Abscess, Development and Symptoms—Temperature—Seat of Abscess—Question as to Multiplicity—Stages of the Morbid Process—Appearances—Terminations—Diagnosis—Treatment—Operations. Phlebitis and Thrombosis of the Sigmoid Sinus and Jugular Vein—Stages in Process and Sources of Infection—Results of Thrombosis—Symptoms—General—Pulmonary, Abdominal, and Meningitic—Local Symptoms—Course—Diagnosis—Treatment—Pyæmia from Aural Disease without Sinus Phlebitis—Symptoms—Diagnosis—Prognosis—Treatment—Ulceration of the Carotid Artery—Conditions under which it occurs—Symptoms—Diagnosis—Treatment—General Tuberculosis and Tubercular Meningitis as Results of Ear Disease.

IN the present chapter, a description will be given of those complications of middle-ear suppuration which are liable to occur in other parts, and mostly within the cranium. The cerebral meninges, the cerebrum, the cerebellum, the arteries and the venous sinuses connected with the temporal bone, may all become implicated in consequence of the spread of carious and suppurative processes from the tympanum. The complications about to be described are all of a serious character, and are often the immediate causes of fatal results in cases of middle-ear disease.

It is difficult to obtain a correct estimate of the number of cases of intracranial disease caused by middle-ear suppuration. In the Registrar-General's reports, about 400 deaths are included as occurring annually in this country from diseases of the ear (otitis and otorrhœa). But it is certain that many additional fatal cases, classified under "meningitis" and other headings, would, if traced to their origin, prove to be examples of intracranial lesions due to suppuration within the temporal bone. The proportion of deaths from aural diseases to deaths from other causes has been estimated at 1 : 158. In 9,000 autopsies made at Guy's Hospital* during twenty years, death was attributable to aural suppuration in fifty-seven cases. Statistics of 8,028 cases, collected by Mr. Barker, yield nearly the same results; but these figures, obtained from hospital records, do not fully represent the frequency or the gravity of the aural diseases. They take no account of those patients who, after a course of treatment in hospitals, succumbed to the disease in their own homes. In addition to these, there is that numerous and increasing class of patients in whom a fatal issue is averted by operations performed in the hospital.

More definite statements can be made with regard to the relative frequency of the various intracranial complications. The reports of 115 autopsies, collected by Dr. Körner,† show that cerebral abscess was present in forty-three cases; sinus phlebitis and pyæmia in forty-one; and uncomplicated meningitis in thirty-one. Similar results are obtained from Pitt's statistics. It must, however, be noted that both cerebral abscess and sinus phlebitis are not infrequently complicated by meningitis. Moreover, to obtain a correct estimate of the frequency of meningitis, the statistics should include those cases of extradural suppuration which have recovered after operation.

Before describing the various intracranial affections which may be caused by middle-ear suppuration, it seems desirable to point out the anatomical conditions which facilitate the extension of pathogenic processes from the tympanum. In a large class of cases, the septic infection spreads by direct contact. A portion of the osseous wall of the tympanum is affected by caries; and perforation takes place, whereby the dura mater is exposed. The spots at which this process most often occurs are the roof of the tympanum and the mastoid antrum, and the groove for the sigmoid sinus (see note on page 61). In another class of cases, extension takes place either in the absence of caries, or when the osseous lesion does not extend to the dura mater; and there are at least four routes through which infectious materials may pass into the cranium: (1) Gaps or dehiscences in the bone; (2) along prolongations of the dura mater extending between the two cavities; (3) through the labyrinth, after destruction of the tissues covering the fenestræ; (4) through minute veins, in which thrombosis takes place, and extends from these to the nearest sinus.

---

* Dr. Pitt's Goulstonian lectures on "Some Cerebral Lesions," *British Medical Journal*, 1890, vol. i. p. 643.

† *Die otitischen Erkrankungen des Hirns, der Hirnhäute und der Blutleiter*, S. 3.

In the *roof* of the tympanum, which forms a portion of the floor of the middle fossa, infection may take place through the petro-squamous fissure, which often exists in children. Through this fissure, a process of the dura mater, containing many small vessels, passes down into the tympanum. Moreover, the little plate of bone is often very thin, and gaps or dehiscences are not uncommon. It is also very liable to be affected by caries. The *floor* of the tympanum forms the roof of the jugular fossa, and sometimes presents dehiscences through which infectious materials may easily pass to the vessel, with thrombosis or ulceration as possible results.

Close to the *anterior* wall of the tympanum is the internal carotid artery; the osseous septum is sometimes extremely thin and presents several gaps. Besides these, there are a few openings through which minute branches of the artery pass to the tympanum. Septic matters may thus gain access to the carotid, and cause either thickening of its walls, purulent infiltration of the tunica adventitia, or ulceration and fatal hæmorrhage. Urbantschitsch* describes another channel of communication between this portion of the tympanum and the interior of the cranium. He states that close to the tympanic orifice of the Eustachian tube, at its upper part, there is often a small opening, leading to pneumatic spaces, surrounding the tympanum and labyrinth and extending forwards to the apex of the petrous portion. On passing a bristle, its extremity becomes visible through a very thin layer of bone, which sometimes presents minute apertures. Fluids injected into the tympanum may be seen to pass through these openings and appear in the cranial cavity.

---

* *Lehrbuch der Ohrenheilkunde*, S. 308.

In the *posterior* tympanic wall, there are several openings leading to the mastoid antrum and cells, into which infectious materials very easily pass. In some instances, the osseous plate separating the sigmoid groove from the mastoid cells is extremely thin; and, besides apertures through which vessels pass, gaps or dehiscences are not infrequent. The structure of the part accounts for the occurrence of sinus thrombosis and abscess of the cerebellum as complications of middle-ear suppuration. There is also another opening in this wall, through which infectious matters may pass into the Fallopian aqueduct, and thence to the internal meatus. This aperture is in the eminentia pyramidalis, and gives passage to the stapedius muscle and a small nerve.

Lastly, septic matters may pass through the *inner* wall of the tympanum, and gain access to the labyrinth and thence to the interior of the cranium. There are several pathways through which infection may take place. The membrane of the fenestra rotunda may be destroyed, and the fenestra ovalis may be opened, after detachment of the stapes. As a result of caries of the upper and posterior part of this wall, the external semicircular canal may be opened. When the labyrinth has been thus exposed, the infection may extend to the internal meatus and the membranes of the brain. Other routes are furnished by the aquæductus cochleæ and the aquæductus vestibuli. There is also the aquæductus Fallopii which leads to the internal meatus. Minute gaps sometimes exist in the wall of that canal, and larger openings may result from caries.

With regard to the *cause* of the intracranial lesions, it would appear that they result from the action of such micro-organisms as are capable of inducing suppurative processes within the temporal bone. It is not necessary to assume that each of the various forms of intracranial disease is due to a special organism. On the contrary, as Dr. Macewen* points out, it is more probable that several intracranial lesions may be due to the same organisms, the incidence of the attack being determined by the pathological condition of the part, and the degree of resistance of the invaded tissues. The middle ear, in a state of chronic suppuration, presents a very suitable nidus for the growth and development of micro-organisms; and the conditions are still more favourable in the mastoid antrum and cells. Inspissated pus and cholesteatomatous deposits in the middle ear are especially dangerous, because they are often infected with peculiar microphytes.

---

* In this and in other portions of this chapter, use has been made of Dr. Macewen's classical work, *Pyogenic Infective Diseases of the Brain and Spinal Cord.*

In the cases under consideration, the micro-organisms most frequently present are the streptococcus pyogenes and the staphylococcus pyogenes aureus. With these, the staphylococcus pyogenes albus and citreus are sometimes associated (Macewen). In one case, the bacillus pyogenes fœtidus was found both in the discharge from the ear and in the cerebral abscess; and the diplococcus pneumoniæ has been detected in the pus of a large meningeal abscess. It often happens that the primary excitants of suppuration in the tympanum are succeeded by other forms of micro-organisms, which may, in their turn, set up the intracranial diseases. Tympanic suppuration may exist for many years without giving rise to any complications, which are often probably due to the invasion of fresh micro-organisms through perforations in the tympanic membrane. This view is supported by the fact that the revival of acute symptoms in cases of chronic otorrhœa sometimes precedes the development of cerebral complications.*

(1) **Cerebral Meningitis.**—Several forms of meningitis may be caused by the extension of infective processes from the temporal bone, in cases of tympanic suppuration. If the process be slowly developed and confined to a small area, it may result in circumscribed inflammation and thickening of the dura mater: the newly formed material prevents the inflammation from extending towards the brain. By pressing, however, upon the cerebral tissue, it may cause symptoms of direct or reflex irritation and more or less active congestion. Portions of the dura mater sometimes become calcified, and the bone itself may be thickened, thus forming an additional barrier to the spread of the disease. On its inner surface, the dura mater may become

---

* For additional information as to the micro-organisms present in cases of acute and chronic suppuration in the tympanum, see pages 339 and 404.

adherent to the arachnoid and pia mater, and the advance of infection is thus decidedly checked.

In another class of cases, a collection of purulent matter is formed between a portion of bone and the dura mater, thus constituting an extradural abscess. This may remain for some time without further change; but, as the result of continued irritation, the dura mater is likely to become softened and perforated (sometimes like a sieve), and the purulent matter passes through to the arachnoid and pia mater. The result may be either a circumscribed collection of pus (subdural abscess); or, in the absence of any barriers to the spread of the infective material, a diffused purulent infiltration of the pia mater in various directions (leptomeningitis). In this manner, the surface of the brain, to a greater or less extent, becomes coated with pus, which also fills up the sulci between convolutions. In severe cases, the dura mater becomes gangrenous, and large openings form, through which portions of brain-tissue, bathed in pus, project into the gaps.

These meningeal lesions sometimes occur alone; but they are not infrequently associated with sinus phlebitis and cerebral abscess. In chronic cases, the exudation is liable to become firm and plastic, and not only fills up the meshes of the pia mater, but adheres closely to the dura mater. The origin of the disease from the affected bone can generally be traced. When the exudation begins on the under surface of the temporal lobe, corresponding to the roof of the tympanum and mastoid antrum, it usually spreads over more or less of the base of the hemisphere; but it may also extend to the convexity, to the base of the other hemisphere, and to the cerebellum. When the infective material finds its way through the labyrinth, the meningitis begins on the surface of the cerebellum; and suppuration may thence spread to the base of the brain, and to the membranes of the spinal cord even down to their termination.

The **symptoms** of cerebral meningitis, due to middle-ear disease, vary in different cases, and are often of an indefinite character. They are also liable to be modified by the coexistence of cerebral abscess and sinus thrombosis. When, in cases of chronic suppuration, the dura mater alone is involved, as a result of disease of the bone, there may be no additional symptoms; and even an extradural abscess may exist for a long time, during which the symptoms are remarkably slight. There is likely to be some increase of temperature and more or less pain; but the disease of the bone may suffice to account for these symptoms. On the other hand, signs of increased pressure would suggest the formation of an extradural abscess. The most important of these are —pain, either confined to the neighbourhood of the ear or spreading irregularly over the head; tenderness on pressure; drowsiness; vomiting; and infrequent pulse. In children, such symptoms are more common and generally more marked than in adults. Inability to understand spoken words—a condition resembling that of a foreigner trying to understand a language with which he is very slightly acquainted—was noticed in a case of large subdural abscess situated above the tentorium.* Stiffness of the neck points to implication of the cerebellum.

In rare cases of extradural abscess, the pus escapes externally either through the ear, through a carious opening in the squamous portion of the temporal bone, or through the mastoid foramen. When discharge takes place through the ear, an opening will be found to exist in the roof of the tympanum; and even the contents of a subdural abscess, having passed through the membrane, may escape in a similar manner. The discharge from the ear of a large quantity of pus, followed by the subsidence of symptoms indicating pressure upon the brain, would raise the suspicion that the case was one of intracranial suppuration communicating with the ear. Escape of pus from an extradural abscess through an opening in the squamous portion or through the mastoid foramen would be preceded by the usual symptoms—viz., pain, swelling, redness, and evidences of fluctuation.

Symptoms of Lepto-meningitis.—In this form of meningitis, the symptoms vary considerably in different cases; they may be divided into two stages, but these are not always distinct. The first symptoms are indicative of cerebral irritation, and are followed sooner or later by those of depression. The onset of the cranial lesion is generally indicated by rigors, followed by fever, and headache; the pain being most acute in the neighbourhood of the ear, and at first perhaps remittent, but soon becoming continuous and extending over the head. The pain is sometimes slight; but in most cases, it is very severe, causing the patient to groan and cry out and to clasp the head with the hands. The pain is soon accompanied by general hyperæsthesia, restlessness, excitement, sleeplessness, giddiness, intolerance of light and sound, nausea and vomiting. Consciousness becomes gradually impaired, and finally altogether lost. Spasmodic contractions of the muscles of the face and limbs on the affected side are soon manifested, together with rigidity of the neck and trismus. Later on, there may be signs of paralysis of muscles supplied by the facial, glossopharyngeal, and hypoglossal nerves; in other cases, there is hemiplegia, or only a single limb is paralysed. The temperature is persistently high and steady, especially when the convexity is attacked. The pupils are contracted; the pulse very frequent, but becoming slower as pressure on the brain increases. Optic neuritis is said to be absent in uncomplicated cases; the disease runs its course before this condition has had time to become developed. It is more often noticed in connection with sinus phlebitis. In fatal cases, death is preceded by unconsciousness, recurring convulsions, paralysis of the bladder and rectum, and profound coma.

---

* Macewen, *loc. cit.*, p. 204. The power of comprehending spoken words was completely restored three weeks after the pus had been evacuated.

The duration of the symptoms varies considerably in different cases. In the majority of cases, death occurs in less than a week after the commencement of the attack. In children, the course is usually more rapid than in adults. There is great diversity in the symptoms; some of those above described are not infrequently absent, and it is thus scarcely possible to draw an accurate general picture of this complaint. A decidedly chronic course is sometimes observed; several weeks or months may elapse before the fatal issue, the symptoms now and then becoming less marked or altogether disappearing.

Körner states that the locality of the meningeal affection may, with more or less accuracy, be inferred from the symptoms. When the cerebrum alone is affected, rigidity of the neck is altogether absent. With disease of the base of the brain, there is often paralysis of the ocular muscles on the same side; and when the convexity is involved, symptoms of irritation and of paralysis on the opposite side are likely to be present. Exudation within the fissure of Sylvius on the left side may cause motor aphasia and agraphia. Affections of the cerebellar membranes are usually accompanied by marked stiffness of the neck: unilateral facial paralysis and deafness are somewhat common, and result from pressure of the exudation upon the nerves implicated. The breathing is sometimes affected, the frequency of the respirations being greatly diminished. Sugar has been found in the urine in a case in which there was exudation in the fourth ventricle; and symptoms of implication of the spinal meninges are not uncommon.

Diagnosis.—Symptoms such as those above described, developing either suddenly or gradually in a patient suffering from acute or chronic suppuration in the tympanum or mastoid portion, generally indicate meningeal complications. It must, however, be borne in mind that grave symptoms, closely resembling those of meningitis, may be caused by obstacles to the escape of secretion in cases of middle-ear suppuration. Thus rigors, high fever, vomiting, delirium, and stupor, occurring in cases in which the pus was pent up within the tympanum, have been observed to subside after incision into the tympanic membrane (see page 413). Meningitis may be inferred to exist when marked sensorial disturbance is associated with clonic and tonic spasms of the muscles of the limbs or with hemiplegia. Symptoms of meningeal inflammation are sometimes prominent in cases of sinus phlebitis and cerebral abscess; and it may be very difficult to determine which of these conditions is actually present. All three may indeed coexist. When, however, in a case of otitis media, grave symptoms become rapidly developed, it is almost certain that the meninges alone are affected.

Treatment.—When symptoms of meningitis manifest themselves in a case of middle-ear disease, the part should be thoroughly examined, and steps taken to remove any existing obstruction to the escape of purulent matter. It may be that the tympanic membrane is tense and bulges out into the meatus, or a perforation has become occluded; an incision is then required. The meatus may be blocked up by a polypus; this, of course, must be removed, and after such operations, the tympanum must be carefully cleansed and disinfected. If there be evidences of suppuration, or of old deposits in the mastoid cells, or of caries or necrosis, the mastoid process and the attic of the tympanum must be opened, so as thoroughly to expose the diseased parts. In taking any further steps, the surgeon will be guided by the conditions thus revealed. If there be signs of a subdural abscess, opening the skull—to be described under "Cerebral Abscess"—will constitute the proper treatment.

Extensive generalised lepto-meningitis may be regarded as beyond the reach of treatment; it is impossible to remove all the infective purulent material from the meshes of the pia mater. Dr. Macewen,* however, has shown that recovery is possible when purulent lepto-meningitis is recognised in an early stage, and an operation is performed without any delay. He quotes five cases in which the roof of the tympanum was found eroded, the dura mater inflamed, softened, and bathed in pus. "After free incision of the inflamed membranes, purulent intradural exudation escaped, generally in drops, and continued to ooze for some time thereafter." In another case, the base of the cerebellar fossa was involved, the patient exhibiting signs of cerebro-spinal meningitis. All six cases recovered. It may be regarded as certain that the infective process was confined to a limited area, which could be reached by operation. As a matter of course, if the symptoms point to extensive implication of the spinal membranes, operative interference is entirely out of the question.

(2) **Cerebral Abscess.**—Chronic middle-ear suppuration is one of the most frequent causes of cerebral abscess, which is apt to become developed in a very insidious manner. In 173 cases of cerebral abscess, noted by Sir W. Gowers, 102 were of otitic origin. The course of events is generally as follows:—The patient has had a discharge from the ear for a considerable time, *i.e.*, for months or even for years. The discharge is usually more or less offensive, though it may be odourless; the patient's hearing is impaired on that side, and there are occasional attacks of pain. In a large proportion of the cases the ear-affection dates from childhood, and has commenced after scarlatina, measles, or other infectious complaint. The setting-in of acute symptoms may follow exposure to cold, injury to the head, or the development of some inflammatory condition in the throat, the application of caustics to the latter part, or operations on the ear; but, in some cases, no such immediate cause is discoverable.

The first symptom to attract notice is usually severe pain in the ear and adjoining parts; this generally occurs in paroxysms, and is apt to be very intense, but not of so sharp a character as in meningitis. Rigors, nausea, and vomiting are more or less frequent accompaniments of the pain, which is increased by the slightest pressure and by percussion. In some cases, there is pain or aching in the back and limbs; in others, diarrhœa. Pain in the stomach and swelling of the abdomen are sometimes noticed. Giddiness is experienced if the patient attempts to walk, and delirium may be an early symptom. When the abscess is seated in the cerebellum, the pain extends from the side to the back of the head. Aphasia is sometimes present, indicating the third left frontal convolution as the seat of disease. In the early stage, the pupils are generally contracted, and there is intolerance of light; the skin is often hot, the pulse quick, and the tongue dry and parched; subsequently, the patient becomes heavy and drowsy, and the symptoms generally may closely resemble those of continued fever. In other cases, attacks resembling coma supervene and pass off; on the other hand, there may be no loss of consciousness, but only some impairment of sensation. In some patients, it is noticed that all cerebral functions are very slowly performed. Convulsive attacks sometimes occur, and are accompanied by paralysis of various parts. When the face is thus affected, the loss of power is usually on the same side as the aural disease. Paralysis of the third nerve on the same side occurs in some cases of abscess in the temporo-sphenoidal lobe. When the acute symptoms have set in, and while they last, the discharge from the ear often lessens, and sometimes ceases altogether. The odour of the discharge is not of prognostic value; the symptoms of cerebral mischief may set in in cases characterised by non-fœtid discharges. The hearing-power may remain unaltered, but if the abscess involve the auditory nerve, complete deafness will result.

---

* *Loc. cit.* p. 329.

In some cases of cerebral abscess there are no prominent symptoms till a few days before death, when paralysis or convulsions supervene; in others, the disease remains latent until the pus finds its way into the lateral ventricle, or on to the surface of the brain, when symptoms immediately set in. Evidences of optic neuritis are frequently noticed in cases of cerebral abscess, especially in the later stages. According to Dr. Schubert,* this complication may present itself in one of two forms. In the first, which is most often found in cerebral abscess, there is simple neuritis, with capillary hyperæmia of the sheath of the optic nerve and slight obscuration of the margin of the papilla. This is also somewhat frequent in otitis, without intracranial complications. The second form is described as choked disk, with considerable prominence of the papilla. This very often occurs in cases of cerebral tumour, but is exceptional in abscess.

---

* *Journal of Laryngology, Rhinology, and Otology*, April, 1895, p. 311.

The temperature during the initial stage of cerebral abscess is slightly above the normal. This stage, however, is often overlooked. Later on, when sensation has become lessened, the temperature is *generally subnormal*, viz., from 1 to 2 degrees below the "normal." It is very seldom raised, unless some complication (sinus thrombosis, pyæmia, meningitis) co-exist. After the contents of an abscess have been removed by operation, the temperature rises quickly to over 100° and then gradually falls to the normal. But should the abscess burst into the ventricles, or upon the suface of the brain, the temperature increases rapidly from subnormal, at the rate of at least a degree per hour, to 104° or 105° (Macewen). In abscess of the cerebellum (which is liable to be complicated by phlebitis of the lateral sinus and by meningitis), a subnormal temperature is rarely observed.

The pulse in uncomplicated cases is infrequent and full, sinking perhaps to forty or even thirty per minute. Exceptions to this rule occur in cases in which the intracranial pressure is but slightly increased. In the final stage, in fatal cases, the pulse becomes very frequent. The frequency of the respirations is likewise diminished, this symptom being decidedly marked in cerebellar abscess.

Seat of Abscess.—The abscess may form in any part of the brain; the white substance is more commonly affected than the grey, and the temporal lobes are the most frequent seat of the disease. Next in frequency comes the cerebellum; abscess is very rarely found in the pons Varolii and in the peduncle of the cerebellum. Abscess in the occipital lobe is still more uncommon: one such case* has lately been recorded. The locality of the abscess depends upon the place at which the osseous disease affects the cavity of the cranium or the pus gains access to the latter. In the middle cerebral fossa, the roof of the tympanum and of the mastoid cells is the spot usually invaded. In the posterior fossa, the sigmoid groove of the lateral sinus and the posterior wall of the antrum are especially liable to be affected with caries and its consequences. In these latter cases, the seat of the abscess is likely to be in the cerebellum. In rare cases,* cranial infection results from extension through the labyrinthine cavities and the internal auditory meatus. In one hundred and nineteen cases, noted by Körner, there were seventy-nine instances of cerebral and forty of cerebellar abscess. Barr gives results of a compilation of seventy-five cases; in fifty-five, the abscess was in the cerebrum, in the temporo-sphenoidal lobe just above the roof of the middle ear; in thirteen, in the cerebellum; in four, in the cerebrum and cerebellum; in two, in the pons Varolii; in one, in the crus cerebri. In all, the abscess was on the same side as the aural disease. In Lebert's cases, eighty in number, one-fourth of which were due to middle-ear suppuration and caries of the temporal bone, there were fifty-three men, twenty-four women, and three children. In one-seventh of the cases the disease occurred before puberty; the majority of the remaining patients were between sixteen and thirty. This difference is probably due to the greater development of the mastoid cells after puberty. Men are more frequently affected than women; and some authorities state that the right side of the brain is more often attacked than the left. There is, however, no great difference in this respect; both ears are equally liable to be affected with otitis media.

---

* *Archives of Otology*, vol. xxvi. p. 297.

As a general rule, in the cases under consideration, the abscess is solitary. If several were originally formed, they soon coalesce. According to Körner, statements as to multiplicity of abscesses are often incorrect. Such formations occurred in fifteen out of one hundred instances. In nearly all cases, otitic cerebral abscesses are close to the diseased ear or bone upon which they depend; but occasionally the abscess-cavity is separated from the diseased bone by a layer of healthy brain-substance. In such cases, the inflammatory process must have extended along the connective tissue and vessels, without implicating the more superficial parts of the brain. Hence, in a fatal case of middle-ear suppuration, whenever an abscess is found at some distance from the temporal bone, it must not be assumed to be of independent origin: a closer examination may reveal signs of a connection between the abscess and the bone. It must also be remembered that even when the former is obviously dependent upon the disease in the ear, there may be no caries of the bone, and the membranes may appear to be healthy. When the abscess is situated at some distance from the diseased bone, and is separated therefrom by healthy brain-tissue, it may be assumed that micro-organisms have passed into the circulation, or into the connective tissue accompanying the vessels. In one case of middle-ear inflammation, swarms of bacteria were found in the temporal bone, both surrounding the vessels and in the diploetic spaces and in the sheath of the facial nerve. The labyrinth was disorganised, whereas its walls were intact, the mischief having extended by way of the sheaths of the vessels. The cerebellum was the seat of an abscess containing hosts of bacteria and micrococci. Körner asserts that cerebral abscesses, at a distance from the surface, are not due to aural disease. They may be caused (1) by pyæmia, the result of sinus phlebitis; (2) metastasis, from pulmonary abscess or purulent bronchitis ; or (3) by tuberculosis of the cranial bones.

---

* Two cases of this kind are recorded by Barr, *Archives of Otology*, vol. xxvi. pp. 237, 241.

The **Stages of the Morbid Processes** can sometimes be traced on post-mortem examination. The tympanic cavity is filled with pus and débris; its mucous membrane is destroyed, and its walls are carious or necrotic. The dura mater above the roof of the tympanum may be separated from the bone by pus, or may be softened and sloughing, and the middle lobe of the cerebrum is found to contain an abscess which comes close to the under surface. In other cases, the inner wall of the mastoid cells, or the posterior surface of the petrous portion, is carious, and the abscess is found in that half of the cerebellum.

The **Appearance of the Abscess** varies according to its duration. If recently formed, the cavity is generally ill-defined and surrounded by softened cerebral substance, without any appearance of a lining membrane. On the other hand, abscesses which have been formed some time are generally circumscribed by a thick vascular capsule, formed of fibro-cellular elements. The presence of a capsule does not, however, indicate that the abscess has ceased to enlarge. The pus is commonly greenish, viscid, and acid in reaction, and sometimes horribly fœtid; in old-standing cases it is mucoid, green, and alkaline, and on microscopical examination the pus-corpuscles are found to be very few in number, having been converted into fatty and granular débris. The abscess becomes encysted about six weeks after its formation; when solitary, it may become as large as a hen's egg, or even larger. In the cerebellum, the abscess may reach the size of a walnut before causing death. In cerebral abscesses, the pus tends to make its way towards the surface or towards a lateral ventricle. When the abscess communicates directly with diseased bone, and local adhesions have been formed, its contents may pass into the tympanum, and escape into the meatus: such cases have been described as "cerebral otorrhœa."

The existence of an abscess of moderate or large size in the substance of the brain often causes general enlargement of the part, with flattening of the surface of the convolutions and obliteration of the sulci. In rare cases, the pressure causes absorption of the bone, as sometimes occurs in cerebral tumours.

Other parts besides the brain are apt to be involved in cases of caries of the temporal bone. Thus when the mastoid cells are diseased, the lateral sinus is often the seat of thrombosis, and its external surface is coated with pus and lymph. The process may extend along the internal jugular vein, and cause suppurative pleuritis and pulmonary abscess.

In cases of cerebral abscess, the fatal issue most commonly takes place before the end of the first month; but life is sometimes prolonged for six and even eight months. During this period such symptoms as headache, vomiting, and a dull mental condition are more or less prominent. In rare instances, the abscess becomes encapsulated, and a so-called "latent period" ensues, and lasts for a year or more. Death may occur in one of several ways: (1) from pressure and œdema, especially in cerebellar abscess; (2) as a result of bursting of the abscess into a lateral ventricle, or on the surface of the brain; (3) as a result of other co-existing cerebral lesions, *e.g.*, sinus phlebitis and meningitis. It is usually ushered in by delirium followed by stupor and coma, or severe epileptiform convulsions.

The **Diagnosis** of cerebral abscess is by no means easy; but a careful consideration of the history of any given case will aid in the interpretation of the symptoms. When rigors, headache, vomiting, etc., supervene in a patient who has for some time suffered from otorrhœa, the decision will rest between *abscess* and *meningitis*, and possibly a *cerebral tumour*. In abscess, the headache is more continuously felt; it comes on suddenly and remains very severe; in tumour there are more frequent intermissions, and the pain follows the course of certain nerves. Moreover, the patient at times appears to be free from symptoms; whereas in abscess, after their first appearance, evidences of cerebral disorder are never wanting. It must be remembered that middle-ear suppuration may be complicated by a cerebral tumour; in such a case the symptoms are very likely to be misinterpreted.

The diagnosis between *cerebral abscess* and *meningitis* may be quite impossible; the two conditions not infrequently co-exist, and such symptoms as headache, fever, delirium, convulsions, and stupor are common to both. Meningitis is indicated by very marked initial symptoms of fever and cerebral excitement, and by cutaneous hyperæsthesia affecting both sides of the body: cerebral abscess may be expected when the initial symptoms affect one side only, when the convulsions and paralysis are likewise unilateral, and when the patient appears to be stupid and lethargic, and if able to answer questions, replies very slowly and deliberately.

It must not be forgotten that the symptoms of intracranial complications of ear-disease sometimes resemble those of continued fever. The late Dr. Murchison * stated that not a year passed but that several cases of abscess of the brain were sent to the fever hospital as examples of fever. In many of these cases, there had been discharge from the meatus for many years; but the general health remained good, until head-symptoms suddenly came on.

With regard to the locality of the abscess, this, in young children, is usually the temporal lobe. In all cases, the same portion is likely to be affected, if the original disease be limited to the tympanic cavity or has extended to its roof or to that of the antrum. On the other hand, if the sigmoid fossa of the lateral sinus be involved, the abscess will probably be found in the cerebellum. Suppuration in the labyrinth leads to a similar result. Tenderness on percussion over any particular spot may indicate the position of the abscess; but pain occurring spontaneously is not of the same value as a localising symptom. Oculo-motor paralysis indicates disease in the temporal lobe; rigidity of the neck is a symptom of cerebellar abscess.

Treatment.—Intracranial abscess nearly always ends in death, unless the pus escape through the mastoid portion or the external meatus, or is removed by an operation. When the symptoms of abscess become developed, trephining the skull affords the only prospect of relief. The operation is of course a formidable one on account of the risks which it involves, such as, irreparable injury to the brain, septic inflammation of the meninges, and hæmorrhage from injury of a vessel. The diagnosis must be established as clearly as possible, and it must be remembered that the symptoms may indicate, with more or less probability, not only abscess, but meningitis (limited or diffused) and thrombosis.

---

* *Trans. Path. Soc.*, 1858, vol. xviii. p. 8.

In order to explore the temporo-sphenoidal lobe of the brain, the trephine is applied at the termination of a line drawn upwards for three-quarters of an inch through the posterior margin of the meatus at right angles to the base-line (see **D**, Fig. 123). Having exposed the dura mater, the membrane should be carefully examined, and then incised across the opening in the bone. If there be a subdural abscess, the pus is generally found along the squamoso-petrosal suture, and will thus be reached. If no pus be found under the dura mater, an exploratory needle, the size of a No. 4 catheter, is then passed inwards, forwards, and downwards, when pus will escape if the abscess be in the supposed position. After the pus has ceased to flow, a rubber drainage tube should be inserted, and the wound washed with carbolic lotion (1 : 20), and subsequently dusted over with finely powdered iodoform; it is then to be covered with sublimate or iodoform gauze.

Before opening the parietal bone, as above described, the foramen for the mastoid vein should be exposed and carefully examined. If pus escape, mischief may be inferred to exist in the cerebellum, and another spot must be selected for opening the cranium, viz., in the occipital bone, an inch and a half behind the centre of the external auditory meatus, and a quarter of an inch below the base-line (see **E**, Fig. 123). A horse-shoe incision is made through the skin, with its ends above the level of the external occipital tuberosity, and its curve slightly below the level of a line joining the apices of the mastoid processes. After reflecting the skin, the muscles are to be divided by an incision parallel to the superior curved line of the bone. The inferior curved line is a good guide for the opening; the trephine should just encroach upon it. After the circle of bone has been

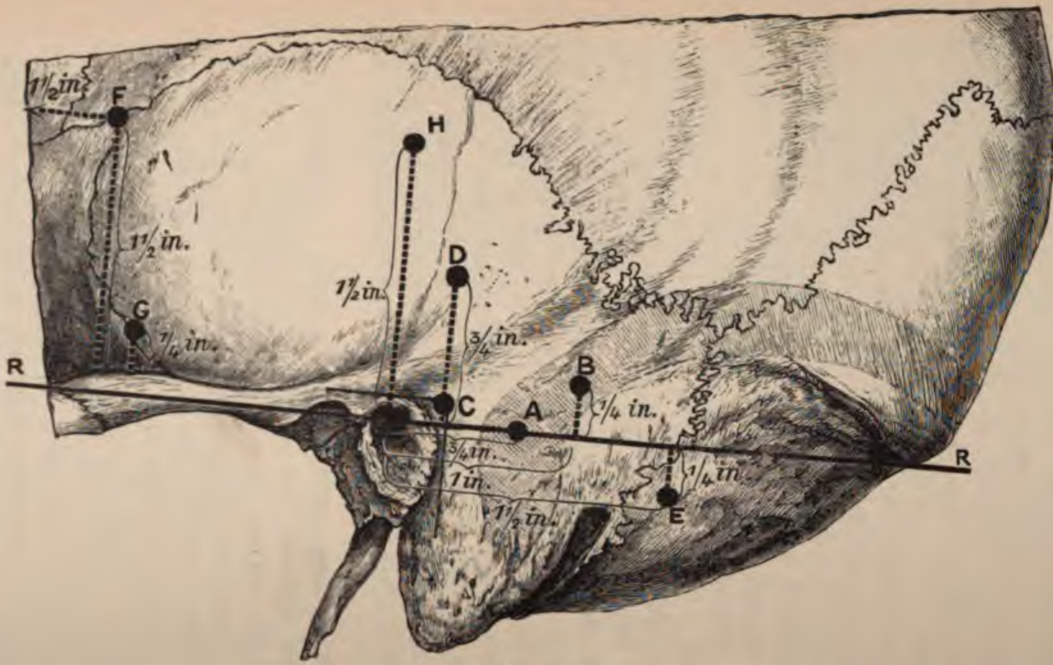


Fig. 123.

Diagram of Adult Skull (*natural size*) showing the various Points for Trephining. (Article by H. P. Dean. Treves' *System of Surgery*, vol. ii.) The horizontal measurements are taken along Reid's base line **RR**, from the centre of the external auditory meatus; the vertical measurements are taken by drawing lines at right angles to the base line. **A**, the sigmoid portion of the lateral sinus, a point ¾ in. along the base line from the centre of external auditory meatus; **B**, the transverse part of the sinus, a point 1 in. from external auditory meatus, and ¼ in. above base line; **C**, the mastoid antrum, the point of meeting of two lines—one drawn along the upper margin of the meatus parallel with the base line, the other along the posterior margin of the meatus at right angles to the base line; **D**, for cerebral abscess (temporo-sphenoidal), a line drawn ¾ in. upwards through the posterior margin of the meatus at right angles to the base line; **E**, for cerebellar abscess, 1½ in. behind centre of external auditory meatus, and ¼ in. below base line; **F**, for anterior branch of middle meningeal artery, 1½ in. from external angular process of frontal bone, and same distance above upper margin of zygoma; **G**, for posterior branch of middle meningeal artery, 1¾ in. from external angular process of frontal bone, and ¼ in. above upper margin of zygoma; **H**, for tapping the lateral ventricle, a point 1½ in. above centre of external auditory meatus.

removed, the dura mater is opened as before, and the cerebellum examined. Should no pus escape, an exploratory needle is passed inwards in various directions for half an inch, or rather more, in the hope of finding the abscess. Should the search prove successful, the wound is to be treated as described in the previous paragraph.

The operation devised by Mr. H. P. Dean* for dealing with the intracranial complications of chronic otitis media is well adapted for overcoming the difficulties likely to be experienced in these cases. He points out that it is often impossible to decide from the symptoms whether the abscess is situated in the temporo-sphenoidal lobe or in the cerebellum. If either has been explored unsuccessfully, the surgeon may be deterred from performing a second operation. In Mr. Dean's plan the surgeon can, with one skin-flap and one opening in the skull, explore both the temporo-sphenoidal lobe and the cerebellum.

The method of operating is as follows: "The bone should be perforated by a trephine or other suitable instrument, at a spot an inch and a quarter behind and a quarter of an inch above the centre of the external auditory meatus (see Fig. 124). By this procedure, a part of the lateral sinus, and the dura mater just above it, are exposed. After slightly enlarging the hole upwards with a pair of sharp-cutting gouge forceps, the dura mater can be incised, and an exploration of the temporo-sphenoidal lobe satisfactorily carried out. If the pus be not found, the opening can be enlarged to a slight extent downwards and backwards, exposing the whole diameter of the lateral sinus and the dura mater for a small extent below it. By incising the dura mater at this spot, the cerebellum can be easily exposed within a few minutes of exploring the temporo-sphenoidal lobe. Only a small area of bone need be removed in order to expose the temporo-sphenoidal lobe, cerebellum, and lateral sinus. The operation need not, at the outside, last more than thirty minutes.

"It is well known that in some cases it is impossible to diagnose cerebral abscess from meningitis. In both cases the most evident symptoms are due to cerebral compression, and it may be impossible to say whether the inflammatory exudation is localised or diffused. If, after exposing the brain, evidence of meningitis is present, and no pus can be found, the lateral ventricle should be tapped by inserting a trochar inwards and slightly upwards, just above the lateral sinus. It is evident that the only satisfactory way of relieving the pressure caused by the inflammatory effusion of meningitis is to drain the lateral ventricle. The patient is dying from the effects of cerebral compression, and by relieving this pressure the only chance of recovery is given. . . . . The symptoms caused by thrombosis of the lateral sinus may be vague, and easily mistaken for those caused by abscess or meningitis. The latter condition may be present with the lateral sinus-phlebitis. By this operation the lateral sinus may be easily examined."

---

* Treves' *System of Surgery*, vol. ii. p. 203.

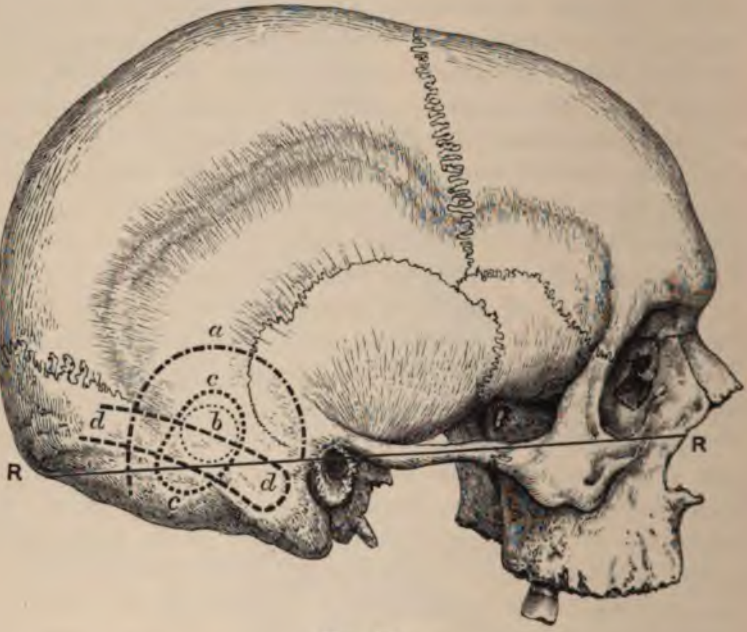


Fig. 124.

Sketch of an Adult Skull to represent an Operation for Treating the Chief Intracranial Complications of Chronic Otitis Media. (Reduced to one-half of natural size.) (Article by H. P. Dean. Treves' *System of Surgery*, vol. ii.)

a, Line of skin incision; *b*, pin of trephine placed $1\frac{1}{4}$ in. behind, and $\frac{1}{4}$ in. above, the centre of the external auditory meatus; *c*, area of bone removed by bone-forceps: *d*, outline of the lateral sinus.

(3) **Phlebitis and Thrombosis of the Sigmoid Sinus and Jugular Vein.**—The floor of the tympanum forms the

roof of the jugular fossa, and through this layer of bone, often very thin, infection may extend from the cavity to the commencement of the internal jugular vein, the process being facilitated by the apertures which not infrequently exist in the bony septum. The result of such extension may be either inflammation of the vein, and thrombosis, or destruction of its coats and fatal hæmorrhage.

The sigmoid sinus is liable to be similarly affected as a result of extension of inflammation from the tympanum to the mastoid antrum and cells. The following is the usual course of events: chronic suppuration in the tympanum is accompanied with caries of the thin layer of bone separating the sinus from the antrum and middle ear. In the next stage, there is inflammation of the wall of the sinus, which becomes thickened and covered with granulations; these protrude into the openings in the diseased bone. The resulting infective thrombosis is attributable to pathogenic organisms. Septic infection of the sigmoid sinus is often preceded by and associated with an extradural abscess. Less frequently the superior petrosal sinus becomes inflamed and contains thrombi, as a result of disease of the petrous portion.

In a small proportion of cases, the sinus is not infected by contact with diseased bone, or by an extradural abscess, but by thrombosis resulting from infectious thrombi projecting into the sinus from small vessels in the bone (osteo-phlebitis); in other cases, the disease of the bone leads to phlebitis of the mastoid vein, and this may extend to the sinus. More rarely, a vein in the dura mater becomes infected by contact with necrosis or caries in the roof of the tympanum, and extension takes place. There is yet another route, viz., the internal auditory vein, through which infectious materials may pass into the inferior petrosal sinus and jugular vein.

The processes to which the infectious thrombosis is due are seldom confined to the spot wherein they originated. The thrombus generally extends forwards with the blood-current and also in the opposite direction. In the cases under notice, formation usually begins in the sigmoid sinus. The thrombus may thence extend (1) forwards for some distance into the jugular vein, and even into the vena cava; (2) backwards into the lateral sinus, even as far as the torcular Herophili, and, in rare cases, to the superior longitudinal sinus, or to the lateral sinus of the opposite side; (3) to one or other of the petrosal sinuses, and thence to the cavernous sinus and ophthalmic vein, and perhaps also to the circular sinus. Extension to the mastoid and to the anterior and posterior condyloid veins is not infrequent.

The wall of the sigmoid sinus may remain for a long time intact, though in close proximity to diseased portions of bone. Cases sometimes occur in which such portions, grooved for the sigmoid and other sinuses, have become detached, but without the vessel having become affected,* although the symptoms of the osseous lesion had existed for several years.

An infective thrombus having formed in the sinus, disintegration and softening of the clot soon take place. The fibrin becomes liquefied, and a pulpy or creamy substance is produced. To this is added more or less pus, derived from the wall of the sinus, which likewise becomes softened and disintegrated. Portions of the thrombus, in the form either of pulp or of distinct fragments, and charged with infective organisms, are likely to pass into the circulation, through the internal jugular vein or through tributary veins, whose current has been reversed. In this manner, the adjacent sinuses and the system generally may become infected. Among the general results, the most serious is the infection of various organs, caused by the dissemination of particles of the thrombus and their arrest in minute vessels, especially in those of the lungs. Other more or less frequent results of thrombosis of the sigmoid sinus are: diffuse suppurative lepto-meningitis, cerebral and cerebellar abscesses, and suppuration in the lymphatic glands along the internal jugular vein. Hæmorrhage from the diseased sinus is rare, inasmuch as the vessel is generally closed by the thrombus.

There is sometimes a history of a fall or a blow upon the ear. Detachment of fragments may possibly be thus caused; but thrombosis is not necessarily connected with any particular injury. Cases of sinus thrombosis appear to constitute about thirty-five per cent. of intracranial affections due to middle-ear disease. Males are much more often affected than females, and the majority of the patients are between ten and thirty years of age. Statistics also show that sinus thrombosis is more common on the right than on the left side (292 : 229).

---

* Two cases of disease of the bone without sinus thrombosis are recorded by Arbuthnot Lane, *British Medical Journal*, 1890. vol. i. p. 1301.

Symptoms.—Sinus thrombosis gives rise to many symptoms, both local and general, and varying greatly in form and degree in different patients. Certain of the symptoms are met with in all cases; while others, of a more definite character and connected with special parts, enable at least three types to be distinguished.

Among the earliest symptoms are rigors, headache, vomiting, and elevation of temperature. These occur in other forms of intracranial disease and in fevers generally. Their coexistence, however, with local symptoms of the primary disorder, such as discharge from the ear and tenderness over the mastoid process, should always excite suspicion. Rigors may be the first marked symptom; they are apt to recur frequently at irregular intervals, and to be followed by profuse perspiration. Their duration varies from a few minutes to an hour or even longer. The oscillations in the temperature are very considerable and often very rapid. It may rise in a few hours to 105° or even 106°, and then fall rapidly to 97° or even lower still. These oscillations may occur twice or even three times in twenty-four hours. Their regular recurrence, every day, every other day, or at longer intervals, is not unusual, and they are not always preceded by shivering. Headache is generally a prominent and an early symptom, and one which causes great distress to the patient. It is sometimes confined to the region behind the ear; but it may be diffused over the side of the head. It is usually increased by pressure or percussion over the mastoid process. Vomiting is generally frequent and severe in the early stages. The appetite fails; the tongue becomes dry and coated; the breath has a peculiarly offensive odour; the bowels are generally relaxed; wasting rapidly goes on, and weakness becomes more or less marked. The pulse is quick and small.

The symptoms just described correspond in the main with those of pyæmia. Their occurrence in a case of middle-ear disease makes them especially significant. Other and even still more important symptoms, pointing to involvement of other parts and of the system generally, may appear in the course of the second week. These, as Dr. Macewen suggests, may be arranged in three groups, viz. (1) pulmonary; (2) abdominal; (3) meningeal.

The *pulmonary* symptoms are due to infarction. Particles of the infective thrombus are carried through the internal jugular vein to the right auricle and ventricle, and thence to the lungs, where their progress is arrested. Inasmuch as the fragments contain an infective poison, they excite active inflammation, and abscesses become developed. These are often very numerous; they are most abundant near the surface of the lung, whence they sometimes break through into the pleural cavity, and cause pleuritis and empyema. The early symptoms may be very indefinite or slight; the patient perhaps complains of cough and attacks of pain localised in various parts of the chest. The expectoration resembles that of pneumonia; but it soon becomes decidedly purulent and very offensive. The physical signs are those of suppurative lobular pneumonia. Diarrhœa is generally superadded; and in fatal cases, death is due to toxæmia and exhaustion. The odour of the breath and of the stools is sometimes so offensive that isolation becomes necessary. Infarctions and abscesses are sometimes found in the spleen and kidneys, and purulent collections may occur in the joints.

In cases belonging to the *abdominal* or *typhoid* group, the symptoms closely resemble those of enteric fever. There is copious diarrhœa, with liquid fœtid stools, of a yellowish colour. Loss of appetite, vomiting, a dry and furred tongue, headache, pain in the abdomen, rapid breathing and pulse, languor, prostration, and delirium help to complete the resemblance. But the rose-red spots of enteric fever are absent, and the irregular oscillations of temperature are characteristic of pyæmia.

When the *meninges* are simultaneously involved, the symptoms will be those of meningitis, as already described (see page 562). Besides headache, vomiting, and fever, the patient will complain of pains in the limbs and restlessness. Evidences of excitement, hyperæsthesia, and delirium soon become manifest, and may be accompanied with tonic and clonic spasms of the muscles of the face and neck, or even with general convulsions. Symptoms of spinal lepto-meningitis, such as girdle pains and marked prostration, have also been recorded.

The **local symptoms** vary in kind and in degrees of prominence. In thrombosis of the sigmoid sinus, the mastoid vein is sometimes noticed to be over-distended; but Dr. Macewen points out that this condition of the vein is dependent upon the extent and site of the thrombus. If the upper part of the sinus be involved, the orifice of the mastoid vein will be included in the thrombus, and the appearance of the vessel externally will be normal. Œdema of the soft parts covering the mastoid process is regarded as another symptom. This, however, is by no means always present; and it often occurs in cases of inflammation of the mastoid process, without any affection of the sinus.

The most important external evidence of thrombosis of the sigmoid sinus is the condition of certain veins connected therewith, and especially of the internal jugular. When this latter is occupied by a thrombus, a cord-like swelling becomes developed on the side of the neck, extending downwards from the articulation of the lower jaw along the inner border of the sterno-cleido-mastoid muscle. The adjacent parts of the neck are œdematous, but not reddened, and the swelling is very painful on pressure. Implication of the deep veins in the upper part of the posterior cervical triangle is somewhat frequent, and is likewise evinced by œdema and tenderness on pressure. The superficial veins of the neck and face, and especially the external jugular vein, are sometimes much swollen; whereas the internal jugular vein, below the thrombus, may be quite empty. Extension to the facial vein is marked by swelling and redness of the cheeks and eyelids; large vesicles are sometimes formed on these parts. The thrombus may also extend through a branch of the facial vein in the orbit to the cavernous sinus.

The swelling in the jugular fossa may encroach upon the glosso-pharyngeal, the vagus, the spinal accessory and the hypoglossal nerve, and cause symptoms either of irritation or of paralysis. The most common symptoms thus caused are tonic or clonic spasms either of the sterno-cleido-mastoid or of the trapezius, supplied by the spinal accessory, the head being drawn either forwards or backwards. When the pneumogastric nerve is affected, there is inability to swallow, loss of voice, cough, infrequent pulse, and paralysis of the muscles of the larynx.

Thrombosis of the cavernous sinus is an occasional result of purulent otitis media, and is due to the extension of a similar process from the sigmoid sinus, through the superior and inferior petrosal sinuses. The prominent symptoms are: exophthalmus, œdema of the eyelids and conjunctiva, increased tension of the eyeball, and loss of vision to a greater or less extent. Pressure by the thrombus may also affect adjacent nerves, causing ptosis and internal strabismus. Other symptoms, such as intolerance of light, supraorbital neuralgia, and profuse flow of tears, would point to implication of the ophthalmic division of the fifth nerve. At the outset, the symptoms are confined to one side; but they may subsequently become bilateral, as a result of extension of the thrombus through the circular sinus. The implication of the second eye sometimes coincides with an improvement in the condition of the other.

The symptoms, as above described, of thrombosis of the cerebral sinuses, resulting from ear-disease, are by no means always present in a uniform manner; several may be absent in any given case, and the diagnosis will become very difficult or even impossible. The course of the symptoms varies greatly; it is sometimes very rapid, death taking place within a few days from collapse or from implication, by metastasis, of some important organs. In other cases, the symptoms run a chronic course, and there are several remissions or intermissions, death at last taking place from pyæmia or exhaustion. Less commonly, the fatal result is due to meningitis, cerebral abscess, hæmorrhage from the sinus, or from paralysis of the pneumogastric nerve. Recovery from thrombosis of the cerebral sinuses is very rare, though a few recorded cases show that its occurrence is not impossible. There is some evidence to the effect that patients presenting typical symptoms may recover for a time, but only to succumb to the secondary effects after intervals varying from two to twelve months.*

The **Diagnosis** of thrombosis of the cerebral sinuses, consequent upon ear-disease, is sometimes difficult, and sometimes clear. Optic neuritis is very suggestive of its existence. In twenty-two cases recorded by Dr. Pitt, the optic disks were stated to be normal only in one instance; neuritis is far less common as a symptom of cerebral abscess. The otorrhœa in cases of thrombosis has generally lasted for months or years; only in rare cases has the affection of the vein or sinuses been noticed to supervene a few weeks after the appearance of the ear-symptoms, and in very acute cases life has lasted only a week or ten days after the development of the vascular lesions. Remittent pyrexia, rigors, and headache are the most constant symptoms; and if the two former continue after the mastoid cells are opened and the tympanum thoroughly drained, there are strong reasons for suspecting thrombosis. Extreme and rapid oscillations of the temperature, taken in connection with the other symptoms, will tend to establish the diagnosis.* Earache, vomiting, coma, delirium, and convulsions are more or less frequently present. In the majority of cases, there is also the hard cord and œdema in the neck, and sometimes the swelling over the posterior part of the mastoid process. Should the case become chronic, the symptoms will more and more resemble those of typhoid fever or septicæmia. There will be considerable emaciation, with a very dry tongue and frequent pulse. The local symptoms will remain as described in a former paragraph; sometimes abscesses form along the course of the internal jugular vein. Acute pulmonary mischief is seldom absent: in three-fourths of the cases, death occurs from pulmonary pyæmia. It must be remembered that thrombosis of the sigmoid sinus may be associated with cerebral abscess and meningitis. In such cases, the diagnosis might be very difficult. The symptoms of the thrombosis are generally the most prominent. They may altogether mask those of the secondary lesions.

---

* See Dr. Newton Pitt's Goulstonian Lectures on "Some Cerebral Lesions," *British Medical Journal*, March 22, 1890.

Treatment.—As soon as sinus-phlebitis is believed to exist, an operation should be performed in order to prevent the dissemination of infectious materials. Symptoms of pyæmia and metastases are not to be regarded as contra-indications; but if the lungs be seriously affected, there is little hope of saving the patient. Still, considering the dangerous nature of the disease and its almost certain issue if left to itself, the operation should be performed even when the chances of success are very small.

As already mentioned (see page 575), Mr. Dean's method of operating for the relief of cerebral abscess can be utilised for the exposure of the lateral sinus. In the majority of cases, however, the mastoid antrum and cells contain more or less purulent matter and débris. These should be freely opened and all morbid contents removed. The most anterior part of the sinus, as it lies in the sigmoid groove, is most often affected; it is therefore best to expose the sinus in this situation, which may be reached by perforating the bone at a spot in Reid's base line one-half to three-quarters of an inch behind the centre of the external auditory meatus (Dean). Any granulation tissue or infective material covering the sinus is taken away, so that the seat of

* See paper by Mr. Ballance, *British Medical Journal*, April 5, 1890, p. 783.

disease is completely exposed. If there be any doubt as to whether the sinus is thrombosed or not, a small hydrocele trochar should be inserted, and if no blood escape, the existence of thrombosis may be confidently assumed.

The following is the plan recommended by Dr. Macewen* for exposing the sigmoid sinus after opening the mastoid antrum:—The sinus should be opened from its anterior aspect, and in doing this, the operator should remove the bridge of bone between the two parts; it often contains the channels through which pathogenic organisms reach the sinus. The anterior knee of the sinus is situated from one-eighth to one-quarter of an inch behind the base line of the supra-meatal triangle. The posterior wall of the mastoid antrum being exposed, an opening is made in the bone behind that point for half-an-inch horizontally, which, in most cases, will open the greater part of the diameter of the sinus, after which the sigmoid groove may be opened above and below that spot as the disease indicates.

In opening the sigmoid groove, granulation masses often protrude from the dura mater, and pus often oozes out at the same time. If it be considered advisable to open the sigmoid sinus and turn out its disintegrating contents, then quite a vertical inch ought to be first exposed, so as to facilitate the subsequent measures. Sometimes, as a result of ulceration of the wall of the sinus next the bone, the contents of the vessel are exposed to view; they should then be gently removed or washed out. Any space between the groove and the sinus should also be cleared out and rendered aseptic. From granulations protruding from the dura mater, there may be a fistulous track, communicating with an abscess in the cerebellum. Such a track must be carefully examined with a probe; and if it lead to an abscess, the latter must be dealt with, as described on page 575.

After the interior of the sinus has been cleansed, and rendered as far as possible aseptic, a mixture of iodoform and boric acid (1 to 4) is thickly powdered over its interior. Its lumen is then obliterated by folding inwards its walls, which were previously split. The space between the sinus and the bone is filled with the same powder, and the external portions of the wound are stuffed with iodoform gauze, so as to permit free drainage and healing by granulation tissue. By thus obliterating the sinus for about an inch of its extent, the flow of blood from the lateral and superior petrosal sinuses is arrested, and efflux from the mastoid vein is likewise prevented.

---

* *Pyogenic Infective Diseases of the Brain and Spinal Cord*, p. 308.

If, on removal of the thrombosed mass, hæmorrhage should occur on the distal side of the sinus, the measures just described will suffice to arrest it. Hæmorrhage from a non-thrombosed sinus is best dealt with by detaching, with a periosteal elevator, a portion of the external wall from its osseous groove, and indenting the loosened wall into the lumen of the vessel, where it is maintained by catgut, or the iodoform and boric acid powder, and supported externally by gauze stuffing.

Admission of air into the sinus can best be prevented by using a small sharp spoon rather than aseptic fluids for removing the thrombus from the side nearest the jugular vein. Dr. Macewen advises that no attempt should be made to place a ligature round the sinus. There would be danger of penetrating the brain-tissue and the large meningeal veins.

In addition to the measures above described for dealing with a thrombosed sigmoid sinus, ligation of the internal jugular vein is sometimes necessary. In some cases,* the symptoms indicate that the vein is especially affected, while the sinus may be comparatively free from clot. Under such circumstances, any operation confined to the sinus would be altogether inadequate.

In Mr. Sutton's case, there was no swelling or tenderness over the mastoid; but at the angle of the jaw there was a large pyriform inflammatory swelling, which terminated abruptly at the upper border of the thyroid cartilage. No cord could be felt below, and it was thought that this part of the vein might possibly be free from septic clot. The best treatment † in such a case is to expose the internal jugular vein as low as possible in the neck, to pass a double tendon ligature round it, and tie it at each end of the incision. The vein is then divided between the two ligatures, and the upper end brought out at the upper angle of the wound. This measure cuts off any connection between the infecting centre and the general circulation. The next step is to expose and examine the sigmoid sinus as already described. When this has been done and the sinus opened, the ligature is to be removed from the upper end of the divided jugular vein, through which a current of antiseptic fluid is directed from the opening in the sinus. If necessary, a short interval may be permitted to elapse between the two operations. It must be remembered, however, that ligature of the internal jugular vein does not entirely prevent the danger of dissemination, for this vein is not the only channel between the sigmoid sinus and the lungs. The posterior and anterior condylar veins and the occipital sinus are large enough to permit the passage of minute particles to the lungs by the numerous venous routes entering the subclavian vein (Macewen).

---

* See a case recorded by Mr. H. H. Sutton, *British Medical Journal*, 1892, vol. i. p. 807.

† See reports of cases operated upon by Mr. Arbuthnot Lane, *British Medical Journal*, vol. ii. 1893, p. 561.

(4) **Pyæmia due to Aural Disease, but not dependent upon Sinus-Phlebitis.**—Reference must be made to this occasional complication of ear-diseases, to which attention has been recently drawn by Arbuthnot Lane, Ballance, and Körner.* There is no doubt that symptoms of pyæmia may be associated with aural suppuration, in the absence of thrombosis of a cerebral sinus, and as the result of osteo-phlebitis. The pyæmic symptoms are apparently caused by the direct absorption of infectious substances into the blood, and they are expressed by the formation of numerous embolic foci in the joints and elsewhere.

Aural suppuration *per se* is a far less frequent cause of pyæmia than sinus thrombosis. The infectious materials pass from the tympanum, or from the adjacent portions of the temporal bone, through minute veins which open into the sinuses and into the veins of the dura mater. The original disease, which is generally of an acute type, may take the form of suppuration extending from the tympanum to the membranous lining of the pneumatic cells, and may run its course without producing any serious changes in the bone. It may, indeed, come to an end after escape of pus through an opening in the tympanic membrane, either spontaneous or the result of an incision. In most cases, however, the bone becomes implicated, but without giving rise to any marked external signs.

Symptoms.—These closely resemble those of pyæmia due to sinus-phlebitis. Rigors are sometimes absent; and cases in which the fever presents a decidedly remittent type are not uncommon. According to Körner, the two kinds of pyæmia differ greatly from each other in the form and frequency of the metastases. In pyæmia due to sinus-phlebitis, embolic metastases are common; but they are rare in cases due to osteophlebitis. Moreover, in the former, metastases are generally confined to the lungs, and rarely occur in other parts; in the latter form, a precisely opposite proclivity is manifested; pulmonary metastases* are rare, but purulent collections in the joints and muscles are commonly noticed. This difference is presumably due to the fact that in osteo-phlebitis, the micro-organisms are not enveloped in comparatively large fragments of thrombi, and can therefore pass through the pulmonary capillaries into the general circulation.

---

* *Die otitischen Erkrankungen des Hirns*, etc., S. 86.

The articular deposits are most often found in the shoulder and sterno-clavicular joints. Suppuration is not the invariable rule; in the joints, as well as in the muscles, there is sometimes only serous effusion and more or less pain. Deposits are also found in the synovial membranes, in the subcutaneous connective tissue, in the eyes, and in the pleural cavities. Deposits in the liver would appear to be very rare.

Diagnosis.—In a case of *acute* suppuration of the middle ear, the continuance of rigors and high temperature, when the secretion can readily escape, would excite suspicion of pyæmia. The diagnosis of osteo-phlebitis would be justified by the development of metastases in the joints, synovial membranes, or muscles.† *Chronic* aural suppuration and signs of deposits in the lungs, would point to sinus-phlebitis, even in the absence of external evidences. If the aural disease be overlooked, the case might be mistaken for one of intermittent or of enteric fever.

Prognosis.—This is decidedly more favourable than in cases of sinus-phlebitis. Spontaneous recovery has been noticed, and in some cases all the symptoms have passed off after proper treatment had been applied to the original disease. Even if abscesses form and have to be opened, they usually heal without causing further trouble. The prognosis is, of course, largely influenced by the state of the general health and by the extent and character of the pyæmic processes.

---

* A case in which there was pulmonary abscess, with recovery, is reported in *Archives of Otology*, vol. xxvi. p. 259.

† See "A Case of Bezold's Mastoiditis, with Pyæmic Symptoms," by J. Hegetschweiler, of Zürich, *Archives of Otology*, vol. xxvi. p. 312.

Treatment.—This consists in removing or neutralising the source of infection. The suppuration in the middle ear must be dealt with as already described; and if there be any symptoms pointing to implication of the mastoid cells, the ordinary operation must be performed. The symptoms may be arrested by these measures; but the recurrence of rigors and metastatic deposits would require the exposure of the sigmoid sinus. If this be found to contain a thrombus, the measures described in a previous page must be adopted. But even if no clot can be detected in the exposed sinus, Mr. Ballance recommends that in all cases of clearly marked aural pyæmia, the vein should be ligatured and the sinus plugged, whether it be clotted or not. This plan was followed in a case recorded by Dr. Deanesly, *Brit. Med. Journal*, 1895, vol. i. page 805. In Mr. Lane's [*] case, in which he tied the jugular vein, there was no thrombosis of the sinus, but a collection of pus between it and the adjacent dura mater and the temporal bone. The application of the ligature, however, was followed by thrombosis. Further experience alone can decide as to the propriety of this treatment.

(5) **Ulceration of the Coats of the Carotid Artery.**—Caries and necrosis of the petrous part of the temporal bone sometimes affect that portion which forms the canal for the carotid artery, causing destruction of the coats of the vessel and fatal hæmorrhage. Such cases are fortunately very rare; the researches of Hessler,[†] Moos, and Steinbrügge[‡] have brought to light some fourteen instances, and another has been recorded by Politzer. In a fatal case recently published by Dr. R. Abbe,[§] a loose sequestrum of part of the cochlea was found in contact with an erosion at the bend of the carotid artery. The destructive process was limited to the tympanic cavity and adjacent walls. The child, two and a-half years old, died six days after the hæmorrhage appeared.

The anterior wall of the tympanum is in close contact with he carotid artery; any gap or deficiencies in the bony septum are of serious import, as they render the artery liable to be involved in inflammatory processes. The vessel, likewise, while passing through the canal gives off minute branches to the cavity, and along these, inflammation may extend to the main trunk, producing thickening of its walls, thrombosis, and ulceration. Gruber alludes to cases of this character, in which the connective tissue forming the sheath of the vessel was much relaxed and infiltrated with pus-corpuscles and fluid exudation.

---

[*] See a paper in *British Medical Journal*, 1890, vol. i. p. 1480, by W. Arbuthnot Lane, on "The Treatment of Pyæmia consequent upon Disease of the Middle Ear, and unassociated with Thrombosis of the Lateral Sinus."

[†] *Arch. f. Ohrenheilkunde*, Bd. xviii.

[‡] *Zeitschrift f. Ohrenheilkunde*, Bd. xiii.

[§] *Archives of Otology*, 1896, vol. xxv. p. 1.

When the arterial wall gives way, the opening is usually found at the junction of the vertical with the horizontal portion, and the corresponding part of the canal is carious or necrotic. Less commonly, there are two openings in the vessel; in all cases, direct communication could be traced between its interior and the tympanum. The blood, of course, pours into the latter cavity, and thence into the meatus; but in one case in which the membrane was intact, hæmorrhage took place through an opening in the floor of the auditory canal, leading to an abscess in the anterior part of the petrous bone. Some constitutional disorder could be traced in the majority of the recorded cases; thus, in eight, there was a history of tuberculosis; in one, of scrofula, and in another, of syphilis. In one case, the necrosis was due to the application of a concentrated acid. In several of the cases, the arterial lesion was accompanied by meningitis and cerebral abscess, the result of the caries and necrosis of the temporal bone.

The **Symptoms** of ulceration and rupture of the carotid artery are sufficiently distinct. Blood streams forth from the ear in more or less distinct jets, or trickles away continuously. It also finds its way through the Eustachian tube into the throat, whence it passes into the stomach or is ejected from the mouth. The ordinary symptoms of loss of blood are soon exhibited; the patient becomes pale, faint, and collapsed. In some cases, death ensued from the first hæmorrhage; in others, the flow ceased and the patients rallied for a while, and the hæmorrhage was repeated at intervals from ten to twenty times, until the fatal result ensued. The time between the latter and the first appearance of the symptoms varied, in the cases alluded to, from five minutes to thirteen days. In several instances, the carotid artery was tied; but all of them terminated fatally.

The **Diagnosis** can seldom be difficult. There is the previous history and symptoms of severe middle-ear suppuration, the sudden discharge of arterial blood from the meatus, and the possibility of arresting the bleeding, at least temporarily, by compressing the carotid artery on that side. In hæmorrhage from the ear from ulceration opening into the sigmoid sinus, the blood is dark-coloured, and the flow is not influenced by compression of the carotid artery.

Treatment.—Compression may first be tried, but after a time it is apt to become too painful to be borne, and its effects are only temporary. Ligature of the carotid will of course arrest the hæmorrhage, which, however, is likely to recur. As the result of the operation in one of the cases alluded to above, the hæmorrhage ceased during nine days, and then reappeared; the carotid artery on the other side was then tied, but death took place three days later from a recurrence of the hæmorrhage. As a matter of course, no permanent result can be expected from injecting styptics into the middle ear, though the hæmorrhage may be thereby checked to some extent for a time. The chlorides of iron and zinc have been employed for this purpose.

(6) **General Tuberculosis.**—There remains one more consequence of middle-ear suppuration to which reference must be made, viz., general tuberculosis. In not a few cases of otorrhœa, the complaint exercises an unfavourable influence upon the general condition of the body, and the majority of such patients die without reaching old age. Perhaps there may not be decided symptoms of phthisis; but emaciation, weakness, and cachexia gradually become more and more evident, and the general results are attributable to the absorption of morbid matters from the cavity of the tympanum or mastoid cells. More than forty years ago, Buhl* pointed out that when pus was collected in an osseous cavity, the walls facilitated the absorption of the morbid materials, and the consequent supervention of miliary tuberculosis. The tympanic cavity is for the most part bounded by osseous walls, and when it is the seat of suppurative inflammation, it closely resembles an abscess situated in a bone.

It would seem at least highly probable that miliary tuberculosis may result from tuberculous disease of the middle ear. But in order to establish the connection in any given case, at least two conditions must be fulfilled. In the first place, the tuberculous nature of the aural disease must be clearly demonstrated; and secondly, the ordinary causes of miliary tuberculosis must be shown to be absent. Acute miliary tuberculosis has been known to follow operations on the mastoid process in tuberculous patients; and such an event has been regarded as sufficient to demonstrate a causal connection between the local disease and the systemic infection. In some of these cases, on post-mortem examination, the tympanum was found to be almost free from secretion, and the operation wound had closed; but many bronchial and mesenteric glands were filled with caseous masses, and similar deposits were found in the lungs and elsewhere. In another class of cases, the development of pulmonary symptoms during the course of middle-ear suppuration must be regarded merely as a coincidence. It is also highly probable that in a case of latent tuberculosis, an attack of acute middle-ear suppuration (due to pyogenic micro-organisms) might cause recrudescence of severe symptoms in the lungs and elsewhere. All these considerations tend to show that when general tuberculosis and middle-ear suppuration coexist, it must not be positively assumed that the case is one of systemic infection originating in the tympanum.

---

* *Zeitschrift für rat. Med.*, 1856. *Wiener Med. Woch.* 1859, S. 195.

Tubercular meningitis is almost always either secondary to some chronic tubercular disease, or a manifestation of acute general tuberculosis. It is probably often directly due to tubercular disease in the middle ear, with which the pia mater is closely connected by means of lymphatic channels. There are also other routes through which infection might take place. In a case of middle-ear tuberculosis, tubercles have been found in the outer coat of the carotid artery. The openings which, when the tympanum is thus affected, often exist in the carotid canal, would facilitate the spread of infection; and the fact that, in tubercular meningitis, the tubercles are often found adhering to the smaller arteries in the pia mater, tends to confirm the view as to the part taken by the blood-vessels and the accompanying lymphatics. Dr. Barr* points out that the internal auditory artery, the terminal branch of the basilar which ramifies in the pia mater, close to the favourite seat of the tubercular deposits, anastomoses freely with the stylo-mastoid artery which supplies the greater part of the blood to the mucous membrane of the middle ear. These vessels are accompanied by plexuses of lymphatics, which presumably act as the carriers of the infective materials; and inasmuch as tubercles often exist in the middle ear in children, the preference of tubercle for the base of the cerebrum may be explained on anatomical grounds.

---

* *Manual of Diseases of the Ear*, p. 291.

CHAPTER XXXV.

LOCAL AND GENERAL AFFECTIONS LIABLE TO CAUSE DISORDERS OF HEARING.

Two Principal Classes—Extension of Morbid Processes and Localisation of Specific Micro-Organisms in Ear—Cerebral Anæmia and Hyperæmia—Cerebro-Spinal Meningitis—Lesions of Cerebral Blood-Vessels—Lesions of the Psycho-Acoustic Centre—Acute Hydrocephalus—Tumours of the Brain—Spinal Diseases—Croup, Diphtheria, and Scarlatina—Measles—Mumps—Influenza—Typhus, Typhoid, and Small-pox—Malaria—Diabetes—Tuberculosis—Syphilis.

MANY diseases, of a more or less grave character, are liable to be accompanied by disorders of hearing and lesions of the auditory apparatus; in some instances, as a direct consequence of the extension of morbid processes, and in others as the result of the constitutional disturbance and of the localisation of specific micro-organisms in portions of the ear.

Almost any morbid process in the brain may cause disorder of hearing, either by directly involving the auditory nerves or nervous centres, or by setting up irritation which is transmitted to those parts. The diseases of the brain and its membranes which most often cause aural complications are hyperæmia and anæmia, encephalitis and meningitis, lesions of the blood-vessels (as in apoplexy), hydrocephalus, and new formations. Any of these conditions may, however, exist without producing auditory disturbance; the occurrence of the latter is for the most part the direct result of pressure upon, or irritation of, the auditory nerve, and if these conditions be absent, there will probably be no functional derangement of the sense-organ.

In another class of cases, the aural complications are produced in a different manner. The diseases with which they are associated are due to the presence in the blood of specific micro-organisms, and these latter are conveyed to the organ of hearing in which they exert their deleterious influences. In some of these diseases, of which scarlatina may be taken as the type, the morbid processes in the ear would appear to result from extension of disease from the throat through the Eustachian tube. In others—*e.g.*, influenza and tuberculosis—the excitants of the aural disease would seem to be conveyed by the vascular or lymphatic channels, for there is no necessary throat-disease as a starting-point and source of the mischief.

The present chapter will be devoted to a consideration, firstly of those local diseases which may affect the ear, and secondly of those general disorders which are more or less frequently attended by aural complications.

Cerebral Anæmia and Hyperæmia, unless associated with organic lesions, seldom cause any serious change in the hearing-power. They may, however, give rise to subjective sensations in the ears, such as noises of various kinds, and to giddiness; and anæmia, as in persons convalescing from severe diseases, is an occasional cause of deafness, which subsides as the general condition improves.

In ordinary meningitis, the auditory nerve and the structures of the labyrinth are seldom affected. In a few recorded cases, purulent inflammation of the ependyma, softening of the floor of the fourth ventricle, purulent infiltration and atrophy of the auditory nerves were found after death. In children who recover, deafness from this cause is usually complete; and for some months afterwards symptoms of loss of co-ordination are generally present. In adults, the deafness is apt to be less marked, but noises in the ears may continue for indefinite periods. In hæmorrhagic pachymeningitis, deafness has been found to be due to extravasation of blood between the fibres of the auditory nerve.

Cerebro-Spinal Meningitis is often accompanied by symptoms of auditory disturbance, and followed by serious lesions of the internal and middle ear. At an early stage of the complaint, pain, noises in the ears, and more or less deafness are frequently noticed, and may continue until the patient becomes insensible. In fatal cases, the following appearances have been observed:

swelling and hyperæmia of the trunk of the auditory nerve, and purulent matter deposited around it; suppurative inflammation of the tympanum, and a similar condition, accompanied by hæmorrhagic effusion, in the membranous labyrinth. The changes in the latter structure may be developed independently of the other aural lesions, and either as a result of the neuritis or by propagation of the mischief along the aquæductus vestibuli and cochleæ. Facial palsy is absent in the majority of cases.

Children are more liable than adults to be thus affected, and the loss or impairment of function generally extends to both ears. Should the meningitis terminate favourably, marked unsteadiness of gait is often associated with the deafness, and is a prominent feature during convalescence. This, however, passes off after a time, but the deafness remains. It is a somewhat remarkable fact that the liability to aural disease is not in proportion to the severity of the meningeal disorder, and different epidemics vary as to the frequency of the complication referred to. Thus, cases have been observed in which the febrile symptoms were of a very acute type, but the aural complications were absent. On the other hand, the latter are sometimes severe and frequent among what may be termed abortive forms of cerebro-spinal meningitis. These last only for a few days, and the symptoms may be so slight as not to prevent the patient from following his employment. It is probable that impairment of hearing and disturbance of equilibrium, as complications of cerebro-spinal meningitis and likewise of simple inflammation of the meninges, are sometimes due to pathological changes in the brain without any lesions in the organ of hearing itself. In some cases the deafness is accompanied by impairment of vision in one or both eyes, by disorders of speech, and symptoms indicating that other nerves are involved.

Cerebro-spinal meningitis is the most common cause of acquired deaf-mutism; and in this connection a special interest is attached to the former disease, inasmuch as a controversy has arisen with regard to the etiology of certain cerebral symptoms of a more or less mild character, but liable to be attended by loss of hearing. In 1882, Dr. Voltolini,* of Breslau, published an account of 187 deaf-mutes, whose malady was due, in his opinion, to otitis labyrinthica, and in whose history he failed to recognise any indication of cerebro-spinal meningitis. On the other hand, Drs. Hartmann[*] and Gottstein[†] have shown that Voltolini's views are erroneous, and that at least in the majority of his cases, the aural affection was the result of epidemic cerebro-spinal meningitis. This conclusion was also adopted by Professor Moos, of Heidelberg, in his monograph on the disease in question.[‡] According to the same authority, when the deafness comes on between the third and tenth day of the disease, the labyrinth is involved by becoming in itself the seat of inflammatory changes; but when the deafness begins on or after the fourteenth day, the internal ear has become affected by extension of inflammation along the auditory nerve.

---

* *Die Acute Entzündung des hautigen Labyrinthes der Ohres irrthümlich für Meningitis Cerebro-Spinalis Gehalten.* Breslau, 1882.

Dr. H. Knapp,[§] of New York, considers that in cerebro-spinal meningitis, the eye as well as the ear may be affected in two ways, viz., by propagation of the inflammation along the optic and auditory nerves—which for the eye at least is the rarer of the two—or secondly, by metastatic inflammation of the interior of the eye and ear. In cases belonging to the second category, the functions of the visual and auditory organs are not always destroyed. Voltolini's theory of an independent otitis intima fails to explain the simultaneous occurrence of disease in the two organs.

The **Prognosis** in the cases under discussion is very unfavourable; improvement is quite the exception when the hearing is much impaired, and any change for the better is seldom permanent. It would seem that those who are able to hear high notes have a better chance of recovering hearing than those who cannot; and in cases of absolute deafness without tinnitus, the supervention of the latter symptom is favourable, as showing a tendency in the auditory nerve to resume its function.

Treatment.—As soon as aural complications are discovered in a case of cerebro-spinal meningitis, cold should be continuously applied to the ear and mastoid process, while the ordinary remedies are used to subdue the fever and other symptoms. After a time the preparations of iodine may be given with the view of promoting absorption. Some good may result from the internal use of pilocarpine, four to six drops of a two per cent. solution, or from the subcutaneous injection of about half that quantity. An ointment containing iodine or iodoform may at the same time be applied to the mastoid process. Neither strychnine nor electricity would seem to be of any use in these cases.

---

[*] *Archives of Otology*, vol. xiii. p. 85.

[†] "Weitere Beiträge zur Neuropathischen Form des Ménièreschen Symptomen-Complex," *Arch. f. Ohrenheilkunde*, Bd. xvii.

[‡] *Ueber Meningitis Cerebro-Spinalis Epidemica.* Heidelberg, 1881.

[§] *Archives of Otology*, vol. xiii. p. 297. See also Dr. McBride's *Diseases of the Throat, Nose, and Ears*, p. 586.

Lesions of the Cerebral Blood-Vessels, including embolism, aneurysm, and rupture, may disturb the function of hearing in various ways; the result, in such cases, depending upon the site of the lesion. When the latter, though small in extent, is situated so as to involve the auditory centres, or any portion of the auditory nerve, the hearing is likely to be very seriously affected. Degenerative changes in the labyrinth, with loss of hearing, are sometimes due to embolism; thus, in a case of endocarditis, the sudden deafness which supervened was found after death to be due to embolism of the internal auditory artery. The same process in vessels at some distance from the ear may likewise cause deafness as a result of secondary processes in the brain. Aneurysm of the basilar artery is liable to cause deafness; in some recorded cases of this kind, the loss of function was for a time intermittent. Hæmorrhage from the cerebral vessels does not frequently produce disorders of hearing; in most of the cases in which this symptom was present, either the pons Varolii or the cerebellum was the part affected.

The frequent occurrence of deafness in connection with lesions of certain parts of the brain has helped to indicate the spots in which the acoustic centres are localised. In several cases in which, after death, the left temporal convolution was found to be the seat of various lesions, such as embolism, softening, tubercle, etc., it had been noticed that the patients had not been able to understand what was said to them, although they evidently heard the sounds of the words. It was therefore assumed that the psycho-acoustic centre was placed in the cortex of the left temporal convolution; and that excitement of the auditory nerve led to the formation in this part of an acoustic representation of words. Destruction or removal of this centre is followed by a condition in which sounds are heard, but the sense of words is not understood; this is termed sensory aphasia or word-deafness. It would therefore seem that the first left temporal convolution is the psycho-acoustic centre. Munk's experiments, however, show that adjacent ganglia must possess the same function; for, after injury to the greater part of the centre, the disorder of hearing subsides in the course of a few weeks.

There would appear to be an analogy between disorders of hearing, due to central lesions, and those of vision, produced by a similar cause; and three forms may be distinguished. The first is simple cortical deafness; the second is psychical deafness, in which the patient is unable to interpret any impressions made upon his auditory nerves; he does not understand what is said to him, and fails to recognise any difference between the barking of a dog and the ringing of a bell, etc. In the third form, or word-deafness, the patient hears the words, and can repeat them, but cannot affix any significance to them. He resembles one who in early youth has learned a foreign tongue, and at a later period has completely forgotten it. This condition of word-deafness is said to be not infrequent in syphilitic disease of the brain, such as gummata of the cortex, and is generally combined with hemiplegia.

Acute Hydrocephalus is sometimes accompanied by deafness, which, should the patient survive, may either subside or remain permanent. In a small proportion of deaf-mutes, the loss of function is attributable to an attack of hydrocephalus in early childhood. The lesions produced by the disease are stated to be inflammatory changes in the floor of the fourth ventricle, and softening and atrophy of the auditory nerve-nuclei. In chronic hydrocephalus, the nerve becomes atrophied from pressure.

In cases of **Tumour of the Brain** sight is far more frequently affected than hearing, and complete deafness is comparatively rare. Such growths sometimes produce deafness when they occupy, or extend into, the space between the internal auditory meatus and the side of the pons. There may be loss of hearing from this cause, without signs of facial paralysis. More or less impairment of function is noticed in about one-thirteenth of all cases. Ladame's statistics show that the hearing was affected in seven out of seventy-seven cases of tumour of the cerebellum; in three out of fourteen of tumour of the middle lobe; while in forty-five other instances, the parts involved being the anterior lobe (twenty-seven), the posterior lobe (fourteen), and the floor of the fourth ventricle (four), there was no disorder of the hearing-function. The affection of the auditory nerve was caused in various ways; the principal changes being atrophy of the trunk or nuclei from pressure; embolism of the internal auditory or basilar artery; extravasation of blood at the base of the brain or in the labyrinth.

The symptoms pointing to implication of the auditory nerve are deafness of various degrees, subjective sensations, and giddiness: the deafness is generally unilateral, but sometimes both sides are affected. Evidences of disorder of vision are very commonly superadded; and in some cases these latter precede the deafness.

Syphilitic Growths in the Brain may involve the auditory nerve, with disorder of function as a result. In a case of this kind, recorded by Wernicke and Friedlander,* a lesion existed in the temporal lobe on both sides. The patient, a woman aged forty-three, had suffered from epilepsy in her youth, and about a year before her death the attacks returned, and were accompanied by deafness, to which aphasia and right-sided hemiplegia were afterwards superadded. She was under treatment for some weeks, with the result that the speech was somewhat improved when she was discharged from the hospital. A month later she returned with her left arm decidedly paretic, but restoration of power in the right arm. There was no further improvement in the speech, and the deafness on both sides was complete. She died a few days afterwards with symptoms of leukæmia. Post-mortem examination showed gummatous softening in both temporal lobes, and lesions indicative of syphilis in many other organs. In the left temporal lobe, the whole of the first and second convolutions and a portion adjoining were occupied by the deposit. In the right temporal lobe, the superior and posterior portions were involved, while anteriorly the deposit extended almost to the parietal lobe.

Disorders of the spinal cord are sometimes attended by disorders of hearing. Thus in locomotor ataxy, noises in the ears, deafness, and auditory hallucinations are not very infrequent. Giddiness is much more common, and may be attributable to lesions of the nerve-fibres supplying the semi-circular canals. Atrophy of the auditory nerve has also been discovered in several cases of ataxy.

---

* Cited by Gruber, *Op. cit.*, p. 626.

It now remains to consider the aural complications which more or less frequently attend certain general disorders, for the most part febrile in character. Chief among these are diphtheria, scarlet fever, measles, mumps, and influenza. Aural diseases are also not infrequently due to tuberculosis and syphilis.

CROUPOUS AND DIPHTHERITIC INFLAMMATION OF THE MIDDLE EAR.

Both these forms of inflammation occur in the middle ear; the diphtheritic form is rarely an independent affection. It sometimes happens that when diphtheria attacks the throat and causes death, the Eustachian tubes and tympanic cavities are found to be occupied by secretions and membranous formations, which latter belong rather to croup than to the original affection, inasmuch as they affect the surface only, and can be more or less easily detached. Croupous deposits sometimes accompany chronic middle-ear suppuration and perforation of the membrane; they take the form of greyish-white patches, and are presumably due to infection from without.

During the last few years, evidence in some cases has been obtained of positive diphtherial invasion of the tympanum by the special bacillus, discovered by Klebs and Löffler. The patients were children who had succumbed to pharyngeal diphtheria, and whose tympanic cavities were filled with secretion. Many cases of diphtheria of the tympanum, associated with a similar affection of the pharynx, have been placed on record. In one of Dr. Hirsch's cases, that of a child twenty-one months old, who had died from diphtheria of the pharynx and larynx, the mucous membrane of the tympanum was greatly thickened, almost obliterating the entire cavity, and was covered with a tenacious membranous deposit. This exudation was found, under the microscope, to consist of a fibrinous network, with many red and white blood-corpuscles and other cellular elements. After the use of Weigert's method for staining, vast numbers of micrococci were discoverable. It is worthy of note that in this, as in similar cases, very slight evidences of inflammation were found in the Eustachian tube, as compared with the pronounced affection of the pharynx and tympanum, and it seemed probable that the morbific agents reached the tympanic cavity by way of the blood-vessels or lymph-channels, and not through the tube. These are instances of so-called hæmatogenous otitis. Two cases of diphtheria of the tympanic cavity without marked implication of the Eustachian tubes have been recorded by Burckhardt-Merian.*

There is no doubt as to the important part played by micro-organisms in the causation of this disease, though inoculations have failed to prove with certainty that diphtheria is due to the presence of any one organism. In three fatal cases of diphtheria, in which the middle ear was invaded, Moos† was unable to discover any micro-organisms in the diseased parts; but in six other cases, micrococci and streptococci were found in abundance. This author supposed that the local symptoms in the ear were caused by the Klebs-Löffler diphtheria bacillus; but that the spread of morbid processes and the general infection were due to the action of staphylococci and streptococci, which are always present in cases of diphtheria. Many of the histological observations of croupous or diphtheritic inflammation of the middle ear were made in cases of naso-pharyngeal diphtheria which had spread through the Eustachian tubes. The Vienna specialists maintain that primary pharyngeal diphtheria is not very often accompanied by a similar affection of the ear; but that if the pharyngeal disease be associated with scarlatina, croupous inflammation of the middle ear is very liable to occur. In Moos's opinion,‡ all that can be said is that the primary pharyngeal diphtheria is *more rarely* complicated with diseases of the middle ear than scarlatinal diphtheria. In many of the recorded cases, it is impossible to state definitely whether the changes should be described as croupous (*i.e.*, superficial fibrinous) or diphtheritic.

In severe cases of diphtheria of the middle ear, the destructive changes are apt to be very considerable. Thus the greater part or the whole of the membrana tympani may be destroyed; the ossicles and osseous walls may be the seats of extensive caries or necrosis; the carotid and facial canals may be opened or broken up; and the mischief may spread to the labyrinth and to the jugular fossa. The process has been known to extend to the external meatus and the auricle. Bezold* has collected the statistics of 185 cases of aural disease associated with scarlatina. Among these there were thirty in which the tympanic membrane was entirely destroyed, and one or more ossicles lost; in fifty-nine, there was destruction of at least two-thirds of the membrane.

---

* *Samml. Klin. Vorträge*, p. 182.

† *Archives of Otology*, vol. xii. p. 264; vol. xx. p. 57.

‡ *Ibid.*, vol. xx. p. 53.

Symptoms.—Diphtheritic inflammation of the tympanum generally affects both sides at the same time and extends to the cavity from the throat. The first symptoms are more or less severe pain, and high fever. Deafness is likewise present; but the patient soon becomes dull and apathetic, and the state of partial unconsciousness is interrupted only by short periods of restlessness and excitement. If it be possible to examine the ear, the tympanic membrane is found to be of a dusky bluish-red colour and much swollen, so that not even the short process of the malleus can be distinguished. This condition of the membrane probably explains the frequent absence of perforation. On the other hand, the structures within the tympanum very soon become disorganised; the ossicles and the structures connecting them together are rapidly involved. In diphtheria associated with scarlatina, the tympanic membrane soon gives way, and is often completely destroyed; the secretion, at first scanty and sero-purulent, becomes copious and thicker, and contains epithelial shreds and portions of diphtheritic membrane. Facial paralysis is not uncommon, and may affect both sides; it is generally due to destruction of the walls of the aqueduct of Fallopius. The process is very apt to extend to the labyrinth, with total deafness as a result of the destruction of the nervous tissue. A similar condition more often follows the disintegration of the sound-conducting apparatus; and young subjects, if life be preserved, are very liable to become deaf-mutes. Extension to the external meatus has been already referred to. The auricular, submaxillary, and cervical glands are always more or less swollen.

In non-fatal cases, the suppuration and purulent discharge may continue for several months. Even if the secretion should cease, the perforation in the tympanic membrane very rarely heals.

---

* *Arch. f. Ohrenheilkunde*, vol. xxi.

Cranial complications—*e.g.*, meningitis, cerebral abscess, and thrombosis of the sinuses—may set in during the suppurative stage, and end rapidly in death.

Prognosis.—This is always bad, for even in comparatively mild cases, more or less structural damage is certain to remain in the tympanum. The prospect is worse in all respects among children; the risk of deaf-mutism has been already alluded to, and if this be avoided the dangers attendant upon chronic suppuration are always present. The treatment will be subsequently described.

OTITIS MEDIA DUE TO SCARLATINA.

Very severe forms of acute middle-ear inflammation are not infrequently developed in the course of scarlatina; statistics show that about five per cent. of all diseases of the ear owe their origin to the latter complaint. The frequency of the complication is due to the association of pharyngeal diphtheria with the scarlatina, the diphtheritic process extending along the Eustachian tube to the tympanum. On the other hand, scarlatina running its course without any trace of diphtheria in the throat may be complicated by severe purulent inflammation of the middle ear.

The frequency with which ear-affections occur during scarlatina varies in different epidemics. In two small outbreaks recorded by Burckhardt-Merian,* there were thirteen cases of middle-ear disease among fifty-one patients. The aural symptoms are usually developed when the throat-affection is at its worst; but in some patients they do not set in until the desquamative stage has been reached. They consist of violent pain in the ears, increase of temperature (which may rise as high as 104°), deafness, and swelling of the auricular, submaxillary, and cervical glands. The mastoid process is sometimes painful and tender on percussion. In children, delirium and convulsions are very apt to occur. Rapid and extensive destruction of the membrana tympani is the characteristic feature of middle-ear inflammation complicating scarlatina. When the affection occurs in the desquamative stage, its onset is accompanied by distinct elevation of temperature, sometimes preceded by rigors. The fever comes on in the evening, and remits during the morning; the pain is apt to extend to the face, along the second and third divisions of the fifth pair. After perforation has taken place, the fever and the local symptoms usually subside; on examining the ear, shreds of diphtheritic membrane can sometimes be detected in the deep part of the meatus, and hæmorrhage is apt to occur when attempts are made to remove them. The discharge is at first slight; but it soon becomes copious, dark-coloured, and offensive. The perforation is always large; sometimes the membrane is wholly destroyed, and after separation of the shreds, the inner wall of the tympanum and portions of the ossicles come into view. Months may elapse before the discharge ceases; granulations are apt to form in the tympanum, on the remains of the membrane, and even in the external meatus.

---

* *Ueber den Scharlach in seinen Beziehungen zum Gehörorgan*, Volkmann's *Sammlung*, No. 182.

Serious impairment of hearing is the almost invariable result of this form of middle-ear suppuration. In eighty-five cases, observed by Burckhardt-Merian, eighteen were totally deaf on one or both sides, while three others became deaf-mutes. Statistics collected from various institutions show that ten per cent. of all cases of deaf-mutism originate in scarlet fever. The loss of hearing-power is not always due to suppurative processes in the middle ear; it may also be caused by adhesions and indurations of the fenestral structures, and by lesions of the auditory nerve. The risk of extension to the cranial contents is another element of danger. Such complications as meningitis, cerebral abscess, phlebitis of the sinus, and facial paralysis, are not infrequent results of middle-ear inflammation due to scarlatina.

Treatment of Middle-Ear Inflammation caused by Diphtheria or Scarlatina.—The complaint is of a very serious character, and requires very careful treatment. Injections of the antitoxin serum should be used as early as possible. When the throat is the seat of diphtheritic patches, the application to the diseased spots of a ten per cent. alcoholic solution of salicylic acid is the treatment which Burckhardt-Merian found to be the most efficacious. The application is made by means of a cotton-wool holder, the little ball of cotton being thoroughly saturated with the solution. A suitably curved holder is used to apply the same remedy to the naso-pharynx and posterior nares, the object being to prevent the extension of the process to the Eustachian tubes, and to disinfect the parts as far as possible.

In adults suffering from pharyngeal diphtheria, an antiseptic lotion should always be applied through the nostrils by means of a spray-producer (see page 275, and also note on page 276 the objection to the employment of a douche). It is absolutely necessary whenever scarlatina is accompanied by swelling and obstruction to respiration in the nasal passages, and by symptoms of nasal catarrh. The object of the lotion is to cleanse and disinfect the nose and naso-pharynx; a syringe is sometimes employed for the same purpose, but if any amount of force be used, the fluid injected is apt to be driven into the Eustachian tubes.

The spray-producer should be used several times daily, its frequency being determined by the severity of the case. At the same time the throat should be frequently painted with an antiseptic lotion. The following formula is suitable:—℞ Ac. Sulphuros. ʒvj., Ac. Carbolic. ʒss., Aq. Destil. ad ℥iij. M.

As a matter of course, the spray-producer cannot always be used for young children; and for such patients an attempt must be made to apply an antiseptic solution to the naso-pharynx and anterior nares by means of a cotton-wool holder. In treating infants, sulphur, in the form of a fine powder, may be applied to the nose and naso-pharynx by means of an insufflator.

In addition to applying local remedies to the mouth and naso-pharynx, bags of ice, of a suitable form, should be kept in contact with the anterior part of the throat, from one mastoid region to the other. Great relief is often soon experienced, and doubtless results from the diminution of the congestion in the naso-pharynx, and a corresponding influence upon the mucous membrane of the tympanum. At first, continuous application of the ice is desirable; but afterwards when the fever shows morning remissions, the ice should be reserved for exacerbations, and withdrawn when these are at an end. Ice may be freely given to the patient to suck; it will aid in relieving the throat-symptoms.

If, in spite of treatment, the ear has become seriously affected, and on examination it is found that the membrane has been destroyed, and the meatus is filled with diphtheritic shreds, as much as possible of the latter may be removed by the aid of a polypus-snare or curette, and an application then made of a 10 per cent. solution of salicylic acid, or the same remedy in very fine powder. These applications are apt to cause pain, which may be considerably relieved by the previous instillation of a 20 per cent. solution of cocaine; but in the course of a week the diphtheritic process will cease, and the parts will speedily assume a healthy appearance. Closure of a perforation is a not infrequent result of this treatment, properly carried out. In cases in which the diphtheritic membrane is already in process of detachment, and suppuration is profuse, boric acid (2 teaspoonfuls to half a pint) should be used, as an injection, three times daily. A solution of perchloride of mercury (1 in 2,000) or carbolic acid (a drachm to ten ounces of water) may be used for the same purpose. Other antiseptic remedies, which may be used, are resorcin (2 per cent. solution); ozonic ether and papain as a pigment or spray (5—10 per cent.). Several German authorities recommend the solution of acetate of aluminium of the German Pharmacopœia (2½ per cent. with water). As a matter of course, constitutional treatment must be adopted throughout the progress of the case. The treatment should be continued until suppuration has entirely ceased; it is only by constant attention that the risk of serious complications can be averted. It must never be forgotten that otorrhœa due to scarlatina is a very dangerous complaint, by reason of the consequences only too likely to follow.

After suppuration has ceased, the ear must be protected from injurious influences of all kinds, and especially from draughts of cold air, moisture, and dust. The danger of a relapse is, of course, greater in cases of permanent perforation; such patients should always keep a piece of absorbent cotton-wool in the meatus, and when washing the part should be careful not to allow any water to reach the tympanum. Should any discharge reappear, recourse must be at once had to the insufflation of powdered boric acid; and if this should fail, rectified spirit, at first more or less diluted, should be instilled into the meatus every second or third day. This last remedy is especially indicated when there is a tendency to moist desquamation.

DISEASES OF THE EAR OCCURRING DURING THE COURSE OF MEASLES.

Recent observations have proved that the ear is more often affected in cases of measles than had generally been supposed. It would appear that all forms of the disease, whether mild or severe, are liable to be accompanied by aural complications, which may occur at any stage and may affect any part of the organ of hearing.

Statistics show that the aural complications occur in about 4 per cent. of all cases of measles; but there are great variations during different epidemics. Among forty cases of measles attended by complications, Tobeitz* found disease of the ears in sixteen patients, and in nineteen among twenty-two fatal cases. Among 147 cases of deaf-mutism, examined by Dr. Roosa,† in seven instances measles was assigned as the cause.

The symptoms occurring in the ears are for the most part as follows:—

At the beginning of, or during the desquamation stage, the patients, usually children, complain of a sudden and violent pricking and deep-seated pain in the ear, generally on one side. There may be no febrile symptoms, but in some cases there are signs of throat-catarrh. On examination, the tympanic membrane appears either reddish-grey and shining, or flattened or even bulged out, dull, pale, greyish-red, or decidedly reddish, unless exudation has taken place into its structure; the radiating vessels are branched and injected. The general appearances are those of tubal and tympanic catarrh, and acute catarrhal inflammation of the middle ear. Hypertrophy of the pharyngeal tonsil is always more or less marked. The function of the part is but little affected, and spontaneous perforation is very rare. Under suitable treatment with gargles and inhalations, the process often comes to a standstill, without the formation of secretion. Sneezing should be avoided as much as possible. In some cases, there is a decided tendency to relapses, during which, symptoms of a more acute type are prone to set in. Very severe pain is then experienced; the tympanic membrane is covered with swollen, whitish shreds of epithelium, and, when visible, is seen to be dull red or greyish in colour. Febrile symptoms are more or less prominent, and the hearing-power is decidedly lessened. Perforation of the membrane occurs on the third or fourth day, when the pain usually subsides. In a small proportion of cases, less frequently than in scarlatina, the aural complication is unattended by any marked symptoms.

---

* *Arch. f. Kinderheilkunde*, vol. viii. p. 321.

† *Archives of Otology*, vol. xiii. p. 70, and *Treatise on Diseases of the Ear*, 7th Edition, p. 707.

The opening is generally situated in the anterior inferior quadrant of the membrane, and is usually indicated by a pulsating reflection of light over a small area. If the somewhat abundant secretion be removed with cotton-wool, a minute opening, perhaps as large as a pin's head, appears as a black spot. In most cases the aperture does not increase in size, but occasionally rapid destruction takes place in the membrane; and sometimes a second or even a third perforation, with a similar tendency to increase in size, is speedily developed. In exceptional cases, the membrane is almost entirely destroyed; but in the majority the progress is favourable, and cicatrisation takes place in from two to five weeks.

The development and course of the aural disease present occasional variations. Sometimes the local affection precedes the outbreak of the general disorder, and tends to make the real nature of the case somewhat obscure. If there be no previously existing throat-complication, the aural disease must be regarded as due to the general affection, and analogous to those evidences of disorder of the respiratory and intestinal tracts which often precede the cutaneous manifestations. In another, but less numerous class of cases, the ear-affection comes on when the eruption is at its height.

As in cases due to other causes, local complications are occasionally superadded. Thus the inflammatory process may spread to the mastoid cells and to the periosteum. The lymphatic glands at the anterior border of the sterno-cleido-mastoid muscle, near its origin, are often enlarged. The antrum is sometimes filled with pus; and acute caries, with or without necrosis, may affect the walls of the tympanic cavity, the ossicles, and parts of the mastoid portion, and cause rapid destruction. Symptoms of meningeal irritation and epidural abscesses are occasional results. The osseous lesions are for the most part of a secondary character; they are most liable to occur when the perforation is small and unfavourably situated for the escape of discharge. Their advent is likewise favoured by the presence of constitutional disorders—*e.g.*, tuberculosis.

Chronic suppurative disorder may follow an acute stage, and be attended by the complications already discussed. The development of polypous growths is not infrequent.

Croupous and desquamative processes may occur in the ear during the course of measles. The general symptoms are then always serious, and one or both external auditory canals are filled up with tough white membrane, which can be more easily detached than that of diphtheria, and soon reappears. In such cases, the discovery of a small perforation may prove very difficult.

Mention must be made of those cases in which the results of measles are confined to the auricle and meatus, and take the form either of circumscribed or of diffused inflammation. These are mostly seen when the eruption is very marked, and papules are somewhat prominent. The latter form largish, bluish-red elevations in the meatus, and, if they become confluent, may cause a severe sensation of tension, which passes off as desquamation sets in. Gangrene of the auricle has been observed in two cases of this kind.

Localisation of the morbid process in the labyrinth occurs in another series of cases. This complication is of serious import; the tympanum may be very slightly affected, transient hyperæmia of the membrane may be all that is noticed. There is, however, more or less pain, marked disorder of equilibrium, and very troublesome tinnitus. After these symptoms have lasted for a few days or even hours, hearing-power is found to be much impaired on one or both sides, or even altogether lost. Such a serious complication seldom occurs in cases of measles; the prognosis is extremely unfavourable.

The pathology of these cases was carefully studied by the late Dr. Moos,* of Heidelberg, who discovered various histological changes in the labyrinth. In one class, these were due to a purely mechanical condition—*e.g.*, coagulation of lymph, aggregation of lymphoid cells, either isolated or in numerous groups, occupying the semicircular canals and ampullæ, the inner cavities of the utriculus and sacculus, the vestibule, etc. Tortuosity and engorgement of the blood-vessels in the petrous bone were other marked changes. and this "globular stasis" resulted in a general thrombosis which extended through the entire labyrinth. The stapedius muscle was in a state of partial degeneration. The coagulation of lymph and the other changes were connected with the presence of micro-organisms. in the forms of monococci, diplococci, and tetracocci.

---

* *Archives of Otology*, vol. xviii. p. 49.

The following statements seem justifiable with regard to the origin of ear-complications in connection with measles:—

The middle-ear inflammation may be the result of exanthematous eruption, or may be produced by irritants brought thither by the current of blood. In a smaller proportion of cases, the aural disease is propagated from the nose or nasopharynx.

Assuming that the changes in the labyrinth are due to micro-organisms, it may be supposed that the necrosis of tissue is either the indirect or the direct result of their presence. They cause fatty degeneration of the endothelium of the vessels and consequent thrombosis, which, in its turn, leads to grave disorder of nutrition, and even death of the affected part. The microbes likewise directly destroy the tissues which they invade, and this effect is particularly manifested in the nervous structures. The trunk of the auditory nerve is still further damaged as a result of hæmorrhage caused by necrosis of the vessels, and the process may be so extensive as to account for the total deafness. In only a very few cases is the loss of function temporary in its character. In such instances, when hearing is restored after two or three weeks, it may be inferred that central changes were the cause of the deafness.

MUMPS AND DISEASES OF THE EAR.

Disorder of hearing has been occasionally noticed in connection with parotitis; but the manner in which the ear is attacked remains doubtful; in some of the cases, the tympanum was the part involved in the lesion. Toynbee[*] pointed out the connection between mumps and deafness, and supposed that the latter was due to some affection of the auditory nerve. "As a general rule, no appearance of disease can be detected in the meatus, membrana tympani, or tympanic cavity." Hinton regarded the sequela as a somewhat common one; but the experience of most surgeons is probably to the contrary effect. Hinton's words are, "Next, or perhaps equal in frequency to scarlatina, in this respect, stands mumps, which has an effect on the nervous apparatus of the ear which has as yet received no explanation, and affords no clue to the use of remedies, every part of the ear being normal, so far as examination can extend, but the function is almost abolished." Sir W. Dalby says that mumps must be included among the causes that induce deaf-mutism, and that on many occasions he has known partial or total deafness to take place during an attack of mumps. Only in the last edition of his work does Politzer make any reference to this disease as a cause of deafness. It would appear that disease of the middle ear is not infrequently associated with the labyrinthine disorder. When, apparently, the labyrinth alone is affected, the deafness may be on one or both sides, and is generally complete and incurable. Gruber records a case in which the swelling of the gland was relatively very slight; but on the third day, the patient, a boy ten years of age, became totally deaf on both sides, and was not relieved by any treatment. The case was a sporadic one, and all the symptoms were of the mildest description. Such cases are explained by assuming a process of metastasis, and are compared with those in which inflammation occurs in the testes and breasts. Various substances may enter the circulation, and cause obstructions and secondary disturbances in organs, such as the labyrinth, with complicated circulatory apparatus, particularly when the escape of blood is in any way hindered. In typical cases, the complete deafness, its rapid occurrence, the absence of marked symptoms of middle-ear disease, and the disturbances of equilibrium which may continue for weeks or months afterwards, tend to prove that the lesion is situated in the labyrinth.

---

[*] *Diseases of the Ear*, p. 361.

Dr. Brunner,* of Zurich, arrives at the following conclusions with regard to deafness after mumps:—(1) The nervous deafness after mumps may be unilateral or bilateral, the former being more frequent. (2) It is complete, and, according to past experience, incurable. (3) It develops rapidly (that is, in a few days) with vertigo and subjective noises, the latter symptoms lasting a long time. (4) There is little or no fever; pain is very seldom complained of, and consciousness is not lost. (5) The complication is noticed in children and in adults, and would seem to be more frequent in the latter.

---

* *Archives of Otology*, vol. xi. p. 102.

The deafness and other aural symptoms occasionally precede the local pain and swelling, and may then be regarded as the evidences of general infection. In most cases, however, the aural symptoms are developed either between the third and eighth day of the complaint, or as the latter subsides. The deafness comes on suddenly and rapidly increases; it is usually accompanied or closely followed by tinnitus, giddiness, pain in the forehead or occiput, and nausea. The patient staggers on attempting to walk; but there is no loss of consciousness. Pain may be altogether absent, and when present, it may last only a few hours. In some cases, an attack of mumps is followed by distinct evidences of meningitis, with subsequent marked unilateral deafness.

The degree of febrile movement varies; the temperature is likely to be high if the otitis occur at an early period. Both ears may be simultaneously or successively affected; but the symptoms are not infrequently confined to one ear, and the right is more prone to suffer than the left. The same difference is observed in the case of the testicles.

On examination, the tympanic membrane and cavity are found normal; but there is absolute deafness for sounds and notes of all kinds. Bone-conduction also is totally lost. The deafness is often permanent, though the other symptoms may gradually disappear. Deaf-mutism is sometimes, though rarely, attributable to mumps. Among 147 cases, two were said to have been caused by the latter affection (Roosa).

Besides this purely nervous lesion, exudative and suppurative middle-ear disorders may occur during the course of mumps. In these cases, the infectious material may be supposed to travel from the gland to the mouth, and thence through the Eustachian tube to the ear, where it gives rise to acute inflammation. The labyrinth is seldom affected.

The inflammation may take another course, and extend to the ear through the Glaserian fissure, which is relatively wider in children than in adults. In those rare cases in which abscess forms in the glands, the matter may, of course, pass directly into the ear.

The aural complications in these latter cases are easily explained; but the case is different with regard to the purely labyrinthine disorders connected with mumps, and at least two different views are held as to their origination. The first regards the inflammation of the parotid gland as a local disease, and the development of the processes in other organs as the result of extension or of metastasis. According to the second view, mumps is a general disorder, which may localise itself in various parts of the body. The affection of the internal ear, possibly amounting in its final stage to atrophy of the auditory nerve, may be regarded as the direct local effect of the general infection, just as occurs in the testicles, ovaries, breasts, kidneys, and prostate gland. These parts, however, differ from the ear in being glandular organs.

We must suppose that the blood contains a specific virus, perhaps like the parasite of malaria, connected with the blood-corpuscles, or some other micro-organism, and that this passes into the internal ear and sets up a plastic or exudative inflammation. The products thus formed do not become absorbed, but are converted into connective tissue extending between the end-organs of the nerves and the parts around, and inducing atrophy of the sentient structures.

Another explanation, suggested by Urbantschitsch,* is to the effect that the changes in the labyrinth are due to reflex action. The irritation of the fibrils of the fifth nerve contained in the gland is conveyed to the labyrinth. This author has seen two cases of deafness consequent upon inflammation of the submaxillary gland. In one of these, the deafness, after lasting four years, subsided for a few weeks, and then recurred and remained unaffected by treatment.

Schwartze's † view is that all the local disorders, including those of the labyrinth, which occur in mumps are due to the migration of a specific micro-organism, the exact nature of which has not as yet been definitely ascertained.

With regard to the treatment of deafness following mumps, a case is recorded by Mr. F. W. Jollye,‡ in which the administration of pilocarpine, at first subcutaneously and afterwards by the mouth, was followed by complete restoration of hearing.

---

* *Lehrbuch der Ohrenheilkunde*, III. Aufl. S. 436.

† *Handbuch der Ohrenheilkunde*, I. Bd. S. 585.

‡ *Archives of Otology*, vol. xxvii. p. 20.

INFLUENZA AND DISEASES OF THE EAR.

During the recent epidemics of influenza, various forms of aural diseases have been noticed as complications of the general affection in a small proportion of cases. These forms may be classified under four heads:—

1. Cases characterised by swelling and hyperæmia of the mucous membrane of the middle ear, with scarcely any or very little loss of function.

2. Cases in which the symptoms are pain in the ear, fever, diffused redness and exudation in the tympanum and redness of the membrane, with more or less secretion, at first sero-mucous and afterwards sero-purulent in character.

3. The purely hæmorrhagic form, and the one most typical of its origin. Either the tympanic cavity or the surface of the membrane may be the source of the hæmorrhage, which may continue at intervals during several weeks. The bleeding in some cases is preceded by the formation of hæmorrhagic vesicles on the tympanic membrane. These vesicles are sometimes ring-shaped, and appear on the membrane after spontaneous perforation or paracentesis. They have also appeared in the external meatus. (See pages 205 and 261.)

4. The fourth form is characterised by severe purulent inflammation of the middle ear, and the process is very apt to extend to the mastoid cells; this portion of the bone is often painful on the first or second day of the disease. Politzer noticed mastoid symptoms in eighteen out of 134 cases. Lemke,* of Rostock, records sixty-four cases of ear-disease in consequence of influenza; opening of the mastoid was required in eleven, and four of these showed acute caries and necrosis.

In some cases of influenza the symptoms point to disorder of the labyrinth, as in two instances recorded by Dr. Moos.† In one of these, the symptoms were those of Ménière's disease; in the other, that of a man twenty-five years of age, there was sudden rupture of the tympanic membrane, with escape of blood, but without giddiness. Hearing was, however, totally lost, and it was inferred that hæmorrhage had likewise taken place into the cochlea.

---

* *Archives of Otology*, 1895, p. 60.

† Schwartze's *Handbuch der Ohrenheilkunde*, S. 582.

It must be observed that these disorders of the tympanum may either be preceded by affections of the naso-pharynx, or may be developed spontaneously, *i.e.*, through the blood as the channel of infection. That this latter is the source of origin in many cases is made probable by the fact that the marked aural symptoms may occur at a very early period, either simultaneously with the fever or very soon after its development.

The hæmorrhages are certainly peculiar, though some authorities refuse to admit their special significance. In cases of influenza, hæmorrhage has been observed to take place from mucous membranes in various parts of the body—*e.g.*, the nose, the bowels, and the female genital organs. That changes occur in the blood is shown by the frequent appearance of a yellowish or jaundiced hue of the sclerotic or of the integument, the diminution of hæmoglobin, the destruction of many red blood-corpuscles, and the swelling of the spleen. Other changes in the vascular system are due to the effects of the disease on the vaso-motor apparatus ; the most noticeable being the alterations in the blood-pressure and the increased permeability of the capillary walls, a predisposing cause both of inflammatory processes and of capillary thromboses. It is also possible that the toxines secreted by the bacillus of influenza may cause necrosis of blood-vessels, and thus play a considerable part in the production of hæmorrhages.

With regard to the bacteria present in the ear in cases of inflammation of the tympanum occurring in the course of influenza, recent investigations have shown that no one species is exclusively found, but that several may exist together or may occur consecutively. These observations are similar to those made in lung-affections connected with the same disease. In these latter, pneumo-cocci and streptococci are first discoverable; but in a later stage the former are far less in number or altogether absent. They return, however, with each exacerbation of the pneumonic symptoms. In the ear the micro-organisms most abundantly present are the pneumo-diplococci, next the streptococcus pyogenes, and lastly the staphylococcus albus and aureus. Several of these are not infrequently present at the same time. All of them have been demonstrated to exist in the secretions escaping after paracentesis, in the discharges from the ear, and in pure cultivations. It is no longer possible to assume that any one organism is the cause of the organic disorders which so frequently occur in the course of influenza. Those organisms which have been discovered would appear to play a secondary part in the causation of the diseases in question.

In connection with the epidemic of 1890–91, various observers have published accounts of micro-organisms which they regarded as peculiar to influenza. Klebs* reported the discovery, in the blood, in almost every case, of a flagellate monadina, a one-celled organism executing marked zig-zag movements. It more or less closely resembled the hæmatozoon found by the same authority in cases of progressive anæmia, and was obviously analogous to the monad which Klebs regards as the true cause of malarious disorders. This protozoon is not present in healthy blood, and Klebs obtained positive results by inoculating dogs with the secretions of influenza.

The presence of such an organism appears to explain many of the symptoms of the protean complaint, and especially the nervous phenomena which often last for months, the evidences of muscular exhaustion, the profuse sweating, and the tedious stage of convalescence. It will also furnish a clue to the development of hæmorrhagic inflammation in the tympanum, the disorders of equilibrium, and the loss of function.

It may be assumed that the micro-organism acts by causing disintegration of blood-corpuscles, and that the resulting caseous masses produce temporary or even permanent capillary thrombosis. Hæmorrhages into the tympanic cavity and membrane are the consequences of the local obstruction in the vessels. Local necrosis becomes developed, and other pathogenic organisms, notably pneumo-diplococci and streptococci, pass into the ear. The protracted character of the stage of convalescence is accounted for by supposing that a long period is necessary for the total removal of the micro-organisms from the blood.

Still more recent researches by Pfeiffer and Kitisato,† in Berlin, have brought to light another micro-organism, which they regard as the source of the influenza virus. This is an extremely minute bacillus, even smaller than the bacillus of mouse septicæmia; it is found in the sputum when the disease is at its height, and also in the blood, and positive results have been obtained from inoculation experiments on monkeys.

---

* *Centralblatt für Bacteriol. u. Parasitenkunde*, No. 5, 1890.

† *Deutsche Med. Woch.*, No. 2, 1892.

According to Dr. Haug, in the influenza epidemic at Munich, 1890–91, aural complications were recorded in about twelve per cent. of all cases, and were confined to the catarrhal and nervous forms of the disease. They were not noticed in the cases marked by gastro-enteric symptoms. According to this authority, the cases with aural complications might be divided into two classes: the first containing those cases in which the disease spread from the throat; and the second, those in which the aural infection was the direct result of the influenza-poison. The first class contained two subdivisions, characterised respectively by the mildness and severity of the symptoms; while the presence of hæmorrhagic inflammation and of nervous affections served, in like manner, to subdivide the second class.

The symptoms belonging to the first subdivision usually appear between the third and the eighth days of the complaint, and consist in more or less marked swelling and hyperæmia of the Eustachian tube, tympanum, and tympanic membrane. The subjective symptoms are comparatively slight; there is more or less pain, sometimes of a pricking character, in the deeper part of the ear and along the tube, but there is little, if any, change in the hearing-function. As a general rule, the symptoms subside in from one to three weeks.

In the more severe form, symptoms of acute middle-ear inflammation become rapidly developed. They consist in pain in the ear and adjacent parts, impairment of hearing and tinnitus, pulsation in the deep part of the organ, redness of the membrane and osseous meatus, appearances of mastoid inflammation, and effusion, first sero-mucous and then muco-purulent, into the tympanum. Perforation of the membrane marks the next stage in the process; the opening usually takes place in the anterior inferior segment, but it is not infrequent in other portions, and sometimes occurs in Shrapnell's membrane. The complaint is generally unilateral, but both sides may be attacked, either together or in succession.

In most cases, the occurrence of perforation is soon followed by amelioration of all the symptoms; the fever subsides and the pain abates, the patient is conscious of a feeling of pressure and pulsating sounds in the ear, and of more or less impairment of function. Under ordinary circumstances and proper treatment recovery is completed in from three to six weeks; but if the mastoid process be involved, caries and necrosis are very prone to occur, and an operation is necessary in order to prevent intracranial complications. Extension to the posterior cranial fossa, epidural abscess * and thrombosis of the lateral sinus† have been noticed as resulting from otitis connected with influenza.

It remains to consider the second class of cases, in which the symptoms are much more serious. The inflammation is of the hæmorrhagic type, and its features are almost peculiar to influenza. The ear-symptoms‡ come on while the patients are suffering from catarrh of the air-passages or from the phenomena of the nervous form of the disorder; the throat is free from any catarrhal changes. The patients are usually adults; young children appear to escape this complication. The attack comes on in the evening or during the night with severe boring pain deep down in the ear; this is sometimes preceded by epistaxis. The pain rapidly increases in intensity, and spreads not only to the forehead, temples and neck, but likewise to the thorax and upper extremity of the affected side. Sounds greatly aggravate the suffering, the evidences of which are very marked.

With the pain the fever also increases, and the loss of function on the affected side soon becomes complete. The membrane is found to be of a dull bluish-red, or even bluish-black colour, convex externally, and marked with dots. In other cases the membrane is either dark-red or scarlet in colour, and its surface is covered with tense hæmorrhagic vesicles,§ some as large as a pin's head and others larger, varying in colour from bluish- to blackish-red: sometimes there is one large vesicle, and the appearances are apt to be most marked on the posterior part of the membrane.

Hæmorrhagic infiltration of the tympanic membrane, without

---

* *Archives of Otology*, 1895, p. 131.

† *Journal of Laryngology, Rhinology, and Otology*. April, 1895, p. 319.

‡ See an exhaustive paper by Dr. R. Haug, "Die Haufigsten Erkrankungen des Gehörorganes bei Influenza," *Münchener Med. Woch.*, 1890, No. 8.

§ *Zeitschrift f. Ohrenheilkunde*, vol. xxii. p. 145.

affection of the cavity, is a less common appearance. Sometimes reddish or blackish ecchymosed spots appear on a reddened or almost normal membrane.

In all the varieties above described rupture of the membrane soon occurs, sometimes within a few hours, and is followed by the escape of dark-coloured blood, either fluid or more or less coagulated. In a small proportion of cases, the hæmorrhage is so profuse that styptic remedies are required. All the former symptoms, with the exception of the deafness, now rapidly subside; and if this course be not observed, some complication—*e.g.*, the development of acute suppuration—may be looked for. More or less purulent discharge, however, usually succeeds the escape of blood, and the symptoms then take the ordinary course. It is a somewhat remarkable fact that in the later stages of a given epidemic of influenza, the ear-complications are apt to be much more severe than at the commencement. The virulence of the organism is supposed to increase as time goes on.

The situation and size of the perforation exercise a decided influence upon the progress of the case; an opening in the posterior superior segment, or in Shrapnell's membrane, and a very small orifice in any situation, will render the progress more tedious and increase the liability to complications. Such obstacles to the escape of secretion tend to the development of mastoid inflammation and suppuration with their attendant dangers; and, unless proper treatment be adopted, the mischief may spread to the bones, and set up caries and necrosis, with sinus-thrombosis or pyæmia as subsequent results. Enlargement of the aperture in the membrane, a free incision behind the ear down to the bone, and opening of the mastoid antrum, are the operative measures likely to be required in such cases. In some instances symptoms of pyæmia are very rapidly developed, and terminate in death. Inflammation of the external meatus is another, but less frequent, complication. It may, however, prove to be severe, and lead to troublesome abscesses in the parotid or cervical regions.

In a very small proportion of cases the aural complication is of a nervous type. The patients are usually free from all catarrhal symptoms, and the troubles in the ear are referable to the sound-perceiving apparatus. In the mildest forms there is simply more or less hyperæsthesia, for notes of all kinds and sounds in general. Vertigo and subjective sensations are usually superadded; but the hearing-power is unimpaired. These symptoms almost invariably subside.

It very rarely happens that evidences of marked disorder of equilibrium make their appearance; but cases have occurred in which this symptom became prominent, and was attended by vomiting and decided impairment of hearing. Even total deafness has been observed, and without any apparent change in the middle ear. This complication is presumably due to the action of specific micro-organisms, conveyed to the labyrinth by the blood-current or by the lymphatics.

DISEASES OF THE EAR ASSOCIATED WITH TYPHUS AND TYPHOID FEVERS AND WITH SMALL-POX.

Typhus.—According to the late Dr. Murchison,* disorders of hearing, and especially deafness, occur in 50 per cent. of all cases of typhus fever. Both the internal and the middle portions of the organ are liable to be affected. The symptoms connected with the former part may appear at the commencement of the disease or not until the period of convalescence. In 130 cases of patients recovering from typhus, Hartmann found that thirty-six had aural lesions; and of these, thirteen were suffering from acute otitis media. In many cases, about the fourth or fifth day of the disease the patients complain of noises in the ears, and especially of ringing sounds, and a few days afterwards the attendants find that there is more or less deafness, and sometimes complete loss of function. In other cases there is intolerance of sound, which is a more unfavourable symptom (Murchison). Nothing abnormal can be detected in the tympanum or middle ear. Both sides are most commonly affected; the symptoms pass off during convalescence, and the function is quite restored. The deafness is possibly due to softening of the internal muscles of the ear.

In another class of cases the middle ear is specially affected, and the symptoms usually begin when the fever is at its height; but, owing to the state of the patient, they may attract little, if any, attention. The symptoms are those of naso-pharyngeal catarrh, extending to the Eustachian tube and tympanum. The patient may complain of uncomfortable sensations in the throat, of more or less deafness, and sometimes of autophony. If the ear be examined, the membrane is seen to be indrawn, and its lustre is increased, while the handle of the malleus is shortened; the cavity of the tympanum is decidedly hyperæmic. Sooner or later, the subsidence of the throat-symptoms is followed by that of the ear-troubles.

---

* *Treatise on the Continued Fevers of Great Britain*, 3rd Edit. p. 177.

There is yet another class of cases in which the symptoms are those of acute middle-ear inflammation; there is very severe pain and marked diminution of hearing-power. Perforation of the membrane sometimes takes place; occasionally, indeed, a copious discharge from the ear is the first symptom connected with the organ. In some cases, rigors, high fever, intense headache, delirium, and even convulsions occur during convalescence, and cease at once on the appearance of the discharge. Other instances* have been recorded, in which the otorrhœa was preceded by profound coma, dilated pupils, etc. The opening is always small, and shows no tendency to enlarge; it is generally in the lower half of the membrane. Speedy closure and restoration of function are the general rule; complications in the labyrinth and extension of the process to the mastoid cells are very seldom noticed.

Typhoid Fever.—Aural complications connected with typhoid fever were noticed in the early part of this century. The additional fact that meningitis may be thus induced was observed and recorded by Louis† in 1841, and by Dr. Peacock‡ some years later. The frequency with which aural complications occur in this complaint would appear to vary in different epidemics; but sometimes the proportion is as high as 4 per cent. All parts of the ear are liable to be affected; the auricle may be the seat of gangrenous ulceration, of furuncles, and of abscesses. Moreover, in severe forms of typhoid, the parotid gland on one side is sometimes the seat of abscess, and the pus may find its way through the fissures of Santorini into the meatus.

---

* See a paper by Drs. G. A. Kennedy and W. T. Gairdner, *Glasgow Medical Journal*, 1865.

† *Recherches sur la Fièvre Typhoïde*, vol. ii. p. 92.

‡ *Medical Times and Gazette*, 1856, No. 13.

In the middle ear, the symptoms vary in character, but assume for the most part two principal forms. In the first of these, the condition is mainly catarrhal, and the Eustachian tube is especially affected. In the second, inflammatory symptoms predominate, and the exudation is manifestly purulent. The former condition is rare; but the second is decidedly common, and may be attended by serious consequences.

In most cases the aural symptoms appear during the later stages of the fever—that is, during the fourth week. The patient complains of pain (not particularly severe) and deafness; the tympanic membrane is hyperæmic, and more or less swollen and opaque. Pain and tenderness over the mastoid process are sometimes present at a very early stage. These symptoms continue for two or three weeks, and may then subside. The complaint, however, not infrequently assumes a more serious type. There is severe and increasing pain, marked deafness, tinnitus, and evidences of decided inflammation of the membrane; bone-conduction is not interfered with. The temperature, which may previously have approached the normal, again rises in proportion to the inflammation.

After a few days perforation occurs, and most commonly in the posterior superior quadrant. This exceptional position is said to be due to the fact that the patient almost constantly lies on his back; multiple perforations are not very rare. The discharge, at first sanious, soon becomes purulent, and contains numerous shreds of epidermis. In a later stage, granulations and polypoid growths are somewhat common. The proliferation and detachment of epithelial cells gradually cease, and the membrane assumes a more normal condition; the perforation appears as a black opening in a red surface.

The subjective symptoms do not subside with the establishment of the perforation; and febrile attacks are apt to recur, especially when the opening becomes blocked up, and the secretion is prevented from escaping. As a general rule, the opening shows no tendency to enlarge.

A marked feature in these cases of middle-ear inflammation connected with typhoid fever is the tendency of the process to extend to the mastoid portion. Such extension occurs very soon after the development of the disease in the tympanum; in some cases indeed it would appear to be contemporaneous with or even antecedent to it. At a very early period there is often tenderness on pressure over the mastoid, and pus may form under the periosteum; and the bone may become either carious or necrotic. So marked is this symptom in some cases, and so early does it appear, that the changes in the bone have been regarded as due to primary ostitis, that is, to inflammation not caused by the condition of the tympanum. Caries of the ossicles is another complication which will greatly prolong the duration of the case. As a general rule, however, inflammation of the middle ear, connected with typhoid fever, gradually subsides, and the parts are restored to their normal condition. If, however, the mastoid complication be severe, and an operation be required, the course is certain to prove tedious. Symptoms of meningeal irritation sometimes appear, and may prove serious; but they are usually transient, and are due only to hyperæmia extending from the labyrinth. In one case, recorded by Dr. Murchison,* the head-symptoms appeared at intervals during more than two years. The patient, a girl aged sixteen, had suffered from typhoid fever, and on the thirty-fourth day, pain in the ear and deafness were complained of. Five days later there was purulent discharge. Three months afterwards there were marked head-symptoms, and the attacks continued for more than two years. During this period there were frequent signs of mastoiditis, and detachment of portions of the bone.

There is yet another class of cases in which the aural complication of typhoid fever affects the nervous structures. The symptoms appear in the early stages of the disease, and consist of very severe tinnitus, the sounds being of a ringing or buzzing character. They are accompanied by a greater or less degree of deafness, affecting generally both sides. Disorder of equilibrium has not been noticed, and no objective changes can be detected on examination.

The course of the aural complication is for the most part favourable, but the local symptoms are apt to reappear during recurrences of fever. Subsidence is, however, the rule; and only in a very small proportion of cases is there any permanent deterioration of hearing-power.

With regard to the cause of these aural complications of typhoid fever, the gangrene of the auricle must be set down as

---

* *Treatise on Continued Fevers*, 3rd Edit., Case No. 59, p. 564.

In the middle ear, the symptoms vary in character, but assume for the most part two principal forms. In the first of these, the condition is mainly catarrhal, and the Eustachian tube is especially affected. In the second, inflammatory symptoms predominate, and the exudation is manifestly purulent. The former condition is rare; but the second is decidedly common, and may be attended by serious consequences.

In most cases the aural symptoms appear during the later stages of the fever—that is, during the fourth week. The patient complains of pain (not particularly severe) and deafness; the tympanic membrane is hyperæmic, and more or less swollen and opaque. Pain and tenderness over the mastoid process are sometimes present at a very early stage. These symptoms continue for two or three weeks, and may then subside. The complaint, however, not infrequently assumes a more serious type. There is severe and increasing pain, marked deafness, tinnitus, and evidences of decided inflammation of the membrane; bone-conduction is not interfered with. The temperature, which may previously have approached the normal, again rises in proportion to the inflammation.

After a few days perforation occurs, and most commonly in the posterior superior quadrant. This exceptional position is said to be due to the fact that the patient almost constantly lies on his back; multiple perforations are not very rare. The discharge, at first sanious, soon becomes purulent, and contains numerous shreds of epidermis. In a later stage, granulations and polypoid growths are somewhat common. The proliferation and detachment of epithelial cells gradually cease, and the membrane assumes a more normal condition; the perforation appears as a black opening in a red surface.

The subjective symptoms do not subside with the establishment of the perforation; and febrile attacks are apt to recur, especially when the opening becomes blocked up, and the secretion is prevented from escaping. As a general rule, the opening shows no tendency to enlarge.

A marked feature in these cases of middle-ear inflammation connected with typhoid fever is the tendency of the process to extend to the mastoid portion. Such extension occurs very soon after the development of the disease in the tympanum; in some cases indeed it would appear to be contemporaneous with or even antecedent to it. At a very early period there is often tenderness on pressure over the mastoid, and pus may form under the periosteum; and the bone may become either carious or necrotic. So marked is this symptom in some cases, and so early does it appear, that the changes in the bone have been regarded as due to primary ostitis, that is, to inflammation not caused by the condition of the tympanum. Caries of the ossicles is another complication which will greatly prolong the duration of the case. As a general rule, however, inflammation of the middle ear, connected with typhoid fever, gradually subsides, and the parts are restored to their normal condition. If, however, the mastoid complication be severe, and an operation be required, the course is certain to prove tedious. Symptoms of meningeal irritation sometimes appear, and may prove serious; but they are usually transient, and are due only to hyperæmia extending from the labyrinth. In one case, recorded by Dr. Murchison,* the head-symptoms appeared at intervals during more than two years. The patient, a girl aged sixteen, had suffered from typhoid fever, and on the thirty-fourth day, pain in the ear and deafness were complained of. Five days later there was purulent discharge. Three months afterwards there were marked head-symptoms, and the attacks continued for more than two years. During this period there were frequent signs of mastoiditis, and detachment of portions of the bone.

There is yet another class of cases in which the aural complication of typhoid fever affects the nervous structures. The symptoms appear in the early stages of the disease, and consist of very severe tinnitus, the sounds being of a ringing or buzzing character. They are accompanied by a greater or less degree of deafness, affecting generally both sides. Disorder of equilibrium has not been noticed, and no objective changes can be detected on examination.

The course of the aural complication is for the most part favourable, but the local symptoms are apt to reappear during recurrences of fever. Subsidence is, however, the rule; and only in a very small proportion of cases is there any permanent deterioration of hearing-power.

With regard to the cause of these aural complications of typhoid fever, the gangrene of the auricle must be set down as evidence of a trophoneurosis, and not as the result of pressure. The affections of the middle ear are in part due to extension from the pharynx, but in still greater measure to the direct action of the micro-organisms contained in the blood. Not only the bacilli of typhoid, but staphylococci, streptococci, and diplococci take part in the causation of the local disease.

---

* *Treatise on Continued Fevers*, 3rd Edit., Case No. 59, p. 564.

The cause of the nervous form of the complication is very obscure. Changes in the blood-current may be assumed to exist, or it may be supposed that the specific virus gains access to the labyrinth and affects the organ of hearing, or causes changes in the nervous elements. In fatal cases, deposits of lymphoid cells, infiltrations of small cells, connective-tissue formations, and fatty degeneration of various parts have been occasionally observed.

Small-pox.—This disease is rarely attended by aural complications; the proportion in which these appear varies from 0·2 to 1·6 per cent. Moreover, they are seen only in the severe forms (confluent and hæmorrhagic), and not in the ordinary type of the disease.

In many cases of severe small-pox the eruption is very marked on the auricle, and shows itself at a very early period. The pustules follow the usual course, and cause great swelling of the part and alteration of shape. Owing to their confluence, large accumulations of pus are sometimes formed. The osseous meatus remains unaffected; but the cartilaginous portion may be quite occluded by the pustules, which cause not only severe pain, but also deafness and noises in the ear. In later stages, some amount of ulceration may take place, and the resulting cicatrisation may produce more or less deformity.

In some cases, however, the aural affection is of a different kind, and is due to extension from the throat. The symptoms are pain, moderate deafness, and a hyperæmic and indrawn condition of the membrane; but these may remain unnoticed when the constitutional symptoms are in any way severe. Occasionally the aural complication is much more serious; the membrane soon becomes perforated, and the symptoms are those of diphtheritic inflammation. In exceptional cases, suppurative inflammation of the labyrinth is superadded. In another class of cases, the Eustachian tubes are the parts most affected; ulceration occurs, and the healing process results in obliteration of the tube.

In the severest or hæmorrhagic form of small-pox, symptoms referable to the ear are usually masked by those of the general condition. On post-mortem examination, the labyrinth has been found in a condition of marked hyperæmia, or presenting circumscribed or diffuse patches of infiltration. Hæmorrhage into the sheath of the nerve is another appearance, and is presumably due to embolism and rupture of vessels.

DISEASES OF THE EAR ASSOCIATED WITH MALARIA.

The organ of hearing is liable to be affected by the malarial poison; and the course of the symptoms thus produced is of a peculiar character. They may be regarded as the local manifestation of the general infection. In comparison with the frequency of malarial fever, these aural complications are decidedly rare; they have indeed been attributed to the quinine employed in the treatment. This assertion may, in some cases, be correct; but in others the symptoms are in all probability due to malaria.

As might be expected, no affection of the external ear has been attributed to the influence of malaria; the symptoms are manifested in the other divisions of the organ of hearing. Their intermittent character is the peculiar feature. In the middle ear, the symptoms occur in several forms. In one set of cases, usually of the tertian or quartan type, after several recurrences of the ordinary attacks, during the cold stage of a paroxysm, the patient complains of noises in the ears, pain in one ear, extending to adjacent parts, and more or less deafness. During the hot stage, the symptoms are greatly aggravated, the pain becoming very intense. On examination, the appearances are those of acute middle-ear inflammation; the membrane is bluish-grey or bright red, the margin is obscured, and there are signs of commencing exudation. During the sweating stage, the symptoms pass away, but recur with fresh attacks.

In other cases the symptoms are of a milder type, and no marked change is discoverable on examination. The patient complains of noises and pulsations in the ears during the attack; but there is little, if any, deafness. Sometimes the aural symptoms occur alone, after the characteristic attacks of fever have ceased. They recur at almost regular intervals, and eventually more or less exudation remains in the tympanum. The connection between these attacks and malaria is rendered probable by the history of the case, by the regularity of their occurrence, and also by the fact that they are relieved or prevented by full doses of quinine, but continue indefinitely if that remedy be withheld.

The local influence of malaria can sometimes be detected in patients suffering from aural diseases. Thus in a case of chronic otorrhœa, malarial influence may show itself in the form of severe attacks of intermittent neuralgia in the ear itself, and radiating to the temple and teeth. These may occur when attacks of fever are altogether absent.

In another and a more distinct class, the nervous structures of the ear are especially implicated. Unless as a result of previous disease, there is no appearance of exudation or inflammation; but the tympanic membrane and the middle ear are quite normal. The symptoms take the form either of neuralgia or of sensory irritation, with or without deafness. The pain is referred to the deeper parts; it comes on at regular intervals, and is usually severe. It may extend to the temple, the circumference of the orbit, and to the mastoid and occipital regions. After lasting for a few hours, it entirely subsides. Recurrence can generally be prevented by full doses of quinine.

It must not be forgotten that intermittent attacks of otalgia may be due to caries of the molar teeth. In cases associated with malaria, removal of the teeth will not relieve the pain; it may indeed have an opposite effect.

Evidences of nervous disorder may also take the form of deafness, coming on at regular intervals and unaccompanied by any visible changes. Intermittent attacks of tinnitus also belong to this class, and may either occur alone or may accompany the deafness. Symptoms resembling those of Ménière's disease sometimes assume an intermittent type.

In all these cases, a history of exposure to malaria, and of attacks of intermittent fever, indicates the employment of quinine in full doses (gr. 5—10 and upwards). It may be advantageously combined with hydrobromic acid, and should be given two or three hours before the expected attack. Croton chloral will serve to relieve the neuralgia.

DIABETES AND DISEASES OF THE EAR.

Diabetes would appear to exercise more or less influence on the course of certain aural diseases, and especially on that of acute middle-ear inflammation. It has been repeatedly noticed in diabetic subjects suffering from acute otitis media, that the mastoid process is especially apt to become involved at a very early period, and that the osseous disease thus set up runs a rapid course, and speedily predominates over the original affection. This complication, however, is by no means peculiar to diabetes; for the mastoid cells are very frequently implicated in ordinary cases of acute middle-ear inflammation. But in diabetic subjects the process in the tympanum may be very slight, and attended with but little discharge, which, however, often contains blood. Whether the difference in this respect is due to variety in the organisms that are present is a point that is still undecided. All that can be said is that the existence of diabetes appears to intensify the destructive processes, and notably in the osseous tissue. Not only the tissue of the mastoid process, but also the walls of the tympanum, may become necrosed. It has been supposed that the diminished alkalinity of the blood in diabetes, by lessening the activity of cells which form antitoxin, may increase the tendency to disintegration. Another complication has been noticed in a diabetic case, viz., thrombosis of the carotid artery, at its bend in the temporal bone, with fatal hæmorrhage as the result.

In diabetic subjects with mastoid complications, the quantity of sugar can be decidedly reduced by appropriate treatment, though increase has been observed after an operation. This change, however, was probably due to the influence of the chloroform.

The existence of diabetes does not contraindicate an operation on the mastoid process; on the other hand, it generally constitutes a reason against delay, so as to avert such consequences of rapid destruction as extension to the dura mater and other intracranial complications. Paracentesis should be performed at an early stage; and the opening in the mastoid, when necessary, should be large and free, so that all diseased tissue can be thoroughly removed. The antrum must, of course, be opened. Surgical interference may, of course, be contraindicated by the state of the patient's health. The coexistence of albuminuria with an advanced stage of diabetes would render an operation hopeless.

TUBERCULOUS DISEASE OF THE MIDDLE EAR.

Tuberculosis of the middle ear is not uncommon; the complaint is, however, generally secondary to tubercular deposits in other organs, and especially in the lungs. A few cases of primary tuberculosis of the temporal bone have been placed on record. Zaufal * reports a case in which a mass of tubercles was imbedded in the compact tissue of the petrous bone, and did not communicate with any of the adjacent cavities. In another instance,† the internal auditory meatus was blocked up by a mass of tubercles as large as a pigeon's egg.

The Eustachian tube is the ordinary channel through which bacilli pass into the tympanum, but they may also escape from the vessels of the periosteum of the middle ear. In the propagation of tuberculosis, the Eustachian tube acts in one of two ways: it either remains normal, and serves merely as a channel for infective materials, the movements of which depend upon variations of air-pressure, or its mucous membrane is the seat of disease, which is continued into the middle ear. Marked patency of the Eustachian tube is observable in some tuberculous patients; and in such cases particles of infective material may be forced into the tympanum during acts of coughing, sneezing, and blowing the nose. When perforation exists in the tympanic membrane, bacilli can easily pass into the cavity from the outer air.

Anatomical Appearances.—The first trustworthy accounts of tuberculosis of the middle ear were given by Schwartze,‡ who described small, grey, miliary nodules on the inflamed and proliferated mucous membrane of the inner wall of the cavity. The patients were children, the subjects of tubercle, suffering from purulent otitis. He likewise described caseous inflammation of the tympanic mucous membrane, occurring almost exclusively in tuberculous subjects. Similar cases were described by v. Tröltsch, who considered that the appearances were due to specific tuberculous processes in the tissues of the tympanum and membrane. In recent times, the diagnosis has been established by the discovery of the tubercle-bacilli.

---

* *Arch. f. Ohrenheilkunde*, II. 174.

† *Ibid.*, vol. v. p. 292.

‡ *Pathol. Anatomie des Ohres*, S. 99.

Tuberculosis of the tympanum occurs in two forms, acute and chronic; these are marked by differences in the anatomical appearances. In the first form, diffuse cellular infiltration of the mucous membrane and proliferation of the cellular elements are the prevailing features. There are few, if any, giant cells, but large numbers of tubercle-bacilli. The result is extensive necrosis of the diseased mucous membrane, the tissues of which become caseous and disintegrated. Great loss of substance necessarily ensues; but this form usually occurs in much debilitated subjects, and death puts a stop to the progress of the local disease. In the second, or chronic form, circumscribed masses of tubercle are first seen in the superficial layers of the mucous membrane; their centres become caseous, and giant cells are developed, but bacilli are not very abundant. Caseous disintegration results in superficial ulcers, and fresh deposits of tubercle take place in the deeper layers. In consequence of inflammatory proliferation of cells and infiltration with leucocytes, the mucous membrane becomes much thickened; healthy granulations may then spring up on the surface, and the deeper deposits may be isolated and rendered harmless by connective-tissue formation. Under favourable circumstances, the process may come to an end with healing as the ultimate result.

In most cases, however, the disease extends, for the caseous masses, detached from the surface, infect other portions of the mucous membrane, and a similar process readily takes place between parts already in contact. Thus the inner surface of the membrana tympani and the whole outer wall of the cavity, the mucous covering of the ossicles and fenestræ, are all liable to be invaded. As deeper layers of the mucous membrane are attacked the bones become involved, and the carious process extends to the ossicles. Destruction of the foot-plate of the stapes or of the promontory lays open the labyrinth, and the tuberculous process extends to the perilymphatic space. Unless the tube be already affected, the process extends thither from the cavity; and the mastoid antrum and cells are likewise apt to be invaded. Portions of the mastoid process are often detached as sequestra, after the formation of abscesses. Caries of the roof of the tympanum is likely to lead to inflammation of the dura mater, which becomes either perforated or much thickened. Carious destruction of the floor of the tympanum may expose the jugular vein or the carotid artery, with fatal hæmorrhage as an almost certain result. The canal of the facial nerve may become involved, and the process may extend along the nerve towards the periphery, or in the opposite direction to the internal meatus. Extension to the cochlea is another possible result. Lastly, when the process has become very severe and chronic, the access and development of other micro-organisms may set up profuse suppuration, or gangrene and fatal septicæmia.

Symptoms.—In the majority of cases, unless perforation had already existed in the membrane, the first symptom noticed by the patient is the sudden discharge of a somewhat large quantity of purulent matter. This is sometimes preceded by sensations of fulness or pressure and impaired hearing; but severe pain, so marked in acute suppurative inflammation of the ordinary type, is always absent. This sudden, painless discharge of pus from the ear is characteristic of the complaint. In all other processes accompanied by purulent exudation into the cavity and rupture of the membrane, acute pain is a constant and early symptom. Its absence should at once excite the suspicion of tuberculosis. There is likewise an absence of any signs of local reaction; the secretion is purulent from the commencement; there are few, if any, granulations in the tympanum or on the membrane, and proliferation of tissue around sequestra is very scanty. Deafness is marked only when deeper parts are involved; it is then often accompanied by noises in the ears. The local affection tends to aggravate the general condition of the patient. It is always of serious import, notwithstanding the comparative mildness of the symptoms.

Diagnosis.—The nature of the case can seldom be ascertained until the membrane has given way and the secretion has escaped. But before these symptoms have appeared, certain changes may sometimes be discovered in the tympanic membrane. It becomes dull and yellowish-grey in colour, and minute reddish-yellow patches are seen on its surface and mark the spots at which perforation takes place. The openings, at first very small, rapidly become larger, owing to suppurative disintegration of their margins. As this latter process extends several openings coalesce, and in this way the greater portion, or even the whole, of the membrane may be destroyed. The rapid enlargement of the openings and their confluence are characteristic symptoms of the disease. With regard to the diagnostic value of bacilli in the discharges, it would seem that the micro-organisms of tuberculosis are by no means always discoverable. Several instances are recorded in which bacilli were abundant in the sputum, but could not be found in the pus discharged from the ear. In other instances there was positive evidence of the presence of bacilli.

Perforation usually exists in the lower half of the membrane, the remainder being pale and greyish-yellow. The mucous membrane, as seen through the opening, is either reddish or yellowish; it is sometimes dotted over with caseous masses, and sometimes ulcerated. When the perforation is larger it may be seen that both malleus and incus are either displaced or wanting; in some cases they are quite covered up by greyish-red masses of granulation. In a subsequent stage, but sometimes even at an early period, the bone, when examined with a probe, is found to be involved; there may be caries of the mastoid process or of the petrous bone, or of the osseous wall of the labyrinth.

Prognosis.—This is very unfavourable, and especially when the aural affection is obviously secondary to tuberculous disease elsewhere. In such cases the process runs an extremely rapid course, owing, perhaps, to the supervention of acute miliary tuberculosis; and life is rarely prolonged for more than a few months after the development of the disease in the tympanum. In some cases, however, otitis media sets in, with sudden perforation and escape of secretion, in which the bacilli of tuberculosis are clearly distinguishable; but decided evidence of pulmonary disease is not obtainable until some time afterwards. In these instances, recovery is sometimes witnessed, and even a large perforation may close. In other cases the perforation remains, and shows no tendency to close. The risk of meningeal and cerebral complications is always present. There may be no acute stage in the aural affection, and but little elevation of temperature. The otorrhœa may set in only a few days before death, while the symptoms of meningeal or cerebral mischief are of still shorter duration.

Treatment.—This is that of chronic suppurative otitis. Antiseptic remedies are especially indicated; and therefore the ear should be carefully syringed out several times a day with a warm antiseptic lotion; afterwards it should be dried with absorbent wool, and, finally, powdered boric acid should be insufflated in the usual manner. As an alternative plan, little plugs of gauze, saturated with antiseptic solutions, may be introduced into the tympanum. Besides those in common use, iodol may be thus employed (Iodol gr. ij.; Sp. Vin. Rect. ♏xx.; Glycerin. ♏xl.). As a matter of course, the ordinary treatment of tuberculosis should be carried out. The patients are generally improved by fresh air, good food, and a warm climate. Injections of tuberculin have been tried; but the results were by no means satisfactory.

SYPHILIS AS AFFECTING THE MIDDLE EAR.

Syphilis affects the structures of the middle ear in a variety of ways. It would appear from Bürkner's statistics that about 5 per cent. of all cases of middle-ear disease, and 7 per cent. of cases of nervous deafness, are due to syphilis. It is certainly a cause of catarrhal processes in the mucous membrane, acting usually by extension from the naso-pharynx. Less frequently, it appears to be associated with acute purulent inflammation of the middle ear.

Perforating gummatous ulcers on the velum sometimes cause this form of disease of the middle ear, which is very favourably affected by constitutional treatment. Brieger[*] cites one case in which the middle-ear affection was due to a primary sore on the tonsil. Primary ulceration of the pharyngeal opening of the Eustachian tube may be caused by the passage of a catheter previously used upon a syphilitic subject, and not thoroughly cleansed (see page 125). The ulceration may be followed by constriction or closure, with catarrhal or purulent inflammation of the tympanum as the result.

The effects of syphilis upon the osseous walls and the periosteum are more definite and serious. They consist of hyperæmia, thickening of the mucous membrane, bony outgrowths from the walls and ossicles, ankylosis, etc. In a case recorded by Kirchner,* the patient, a man aged twenty-nine, had contracted syphilis four years previously, and had been treated during two years for deafness, exudation into the tympanum, and occasional pricking pain. After death, the cavity was found to contain sanious exudation, and the mucous membrane of the promontory was decidedly injected. Examination with the microscope showed thickening of the mucous membrane, small-celled infiltration surrounding the blood-vessels and penetrating their walls. The larger arteries on the promontory were much narrowed, owing to endarteritis syphilitica. This latter process, together with thickening of the adventitia, had led in many places to complete obliteration of the vascular canals, and it appeared probable that the oft-repeated accumulation of serous fluid in the tympanum was due to the changes in the vessels. Corresponding to those parts of the mucous membrane which were most seriously affected, were small bony outgrowths, the result of periostitis, and resembling those found on other bones. The Haversian canals contained similar deposits, together with small-celled infiltration and accumulation of pigment. In the bone itself were many cavities of various sizes and filled with detritus; these resulted from disorder of nutrition consequent upon the obliteration of the vessels.

---

[*] *Klinische Beiträge zur Ohrenheilkunde*, 1896, S. 90.

In cases of hereditary syphilis, with disease of the nose or throat, middle-ear suppuration, with copious fœtid secretion, is not uncommon. Absence of pain and fever has been regarded as characteristic of these cases; but a similar peculiarity is often noticed in tuberculous patients not exhibiting any trace of syphilis. It may be accompanied by deafness, caused by disease of the labyrinth, likewise due to the constitutional disorder. Syphilitic affections of the labyrinth will be described in a subsequent chapter.

In cases of syphilis, gummatous formations are occasionally developed within the mastoid process, and also in connection with the periosteum. In this latter, the swelling is soft and sponge-like to the touch, and gradually increases and diffuses itself in various directions, but causes no acute local or general symptoms. The adjacent cervical glands are more or less enlarged. An incision gives vent to a yellowish-grey, soft mass, consisting of small, round cells. The process may extend to the periosteum of the meatus, forming a swelling in the posterior and superior walls. Under appropriate treatment the swelling may subside; but if left to itself, softening is likely to take place, and an opening follows, either on the surface of the process or within the meatus. The character of the opening, and the ulcer which often results, will serve as a guide to the nature of the case, and similar swellings may appear on other parts of the cranium.

---

* *Arch. f. Ohrenheilkunde*, vol. xxviii. p. 172.

When the formation takes place within the mastoid process, the symptoms are: more or less gradual swelling; pain, radiating over the head, and especially severe at night, and enlargement of the neighbouring lymphatic glands. It may become necessary to open the process, in which case the periosteum will be found to be thickened and easily separable from the bone. The cortical layer is reduced in thickness, and yields readily to the chisel. The cells beneath are found to be occupied by a homogeneous gelatinous mass, containing a few minute fragments of necrosed bone. After all the diseased tissue has been removed, the gap becomes very slowly filled up. The healing process is expedited by full doses of iodide of potassium and suitable hygienic measures.

CHAPTER XXXVI.

INJURIES OF THE TYMPANUM—HÆMORRHAGE IN THE TYMPANUM.

Direct and Indirect Injuries—Causes and Symptoms in both Classes—Escape of Cerebro-Spinal Fluid; its Significance—Other Sources of Watery Discharge from the Ear—Openings in Walls of Tympanum and their possible Consequences—Hæmorrhage in the Tympanum—Causes—Symptoms—Treatment—Hæmorrhage with Perforation or Rupture of Membrane—Treatment.

THE tympanum may be injured either by direct or indirect violence. The first category includes cases in which foreign bodies, corrosive fluids, or heated vapours pass through the meatus and tympanic membrane and gain access to the cavity, and likewise those in which the Eustachian tube is the channel. The second class includes such examples of indirect injury as those which sometimes occur in connection with fractures and fissures at the base of the skull, resulting from falls or blows. Explosions, *e.g.*, of dynamite, may shatter the tympanic membrane and cause dislocation or fracture of the ossicles and gaps in the walls. Defects in the osseous walls of the tympanum may also be caused by disease and by arrest of ossification in early life.

When the tympanum is injured by a foreign body, the consequences vary with the nature and form of the substance and the degree of force with which it acts. Rupture of the tympanic membrane, injury or dislocation of the ossicles, and laceration of the mucous membrane are the immediate effects. If the capsule of the labyrinth or the roof of the tympanum be broken through, escape of cerebro-spinal fluid is likely to follow. Sometimes the facial canal is opened and the nerve injured. In one recorded case, during attempts to remove a foreign body from the tympanum, the floor of the cavity was perforated, with hæmorrhage from the jugular vein as the result.

Direct injury to the structures of the tympanum is sometimes caused by projectiles, and wounds of this nature usually involve adjacent parts. In addition to the ossicles and the walls of the cavity, the injury may affect the chorda tympani nerve.

Symptoms.—When a foreign body, of such a shape as to pass readily through the meatus, is driven into the tympanum, it gives rise to more or less severe pain, hæmorrhage, subjective noises, and deafness. The blood which escapes from the meatus varies in quantity; but the hæmorrhage is generally moderate and ceases spontaneously. In the absence of antiseptic remedies, promptly applied, purulent inflammation of the tympanum with its consequences is very apt to result. Division of the chorda tympani will cause loss of taste in the corresponding half of the tongue, with sensations of pricking, cold, etc. Injuries which involve the inner wall or the roof of the tympanum are to be regarded as especially serious. The former portion of the cavity is in relation with the labyrinth; while the roof, often very thin, is in close contact with the dura mater. Attempts to remove foreign bodies from the tympanum have occasionally resulted in serious injury to these portions of the cavity.

Injuries to the tympanum by heated or corrosive fluids are extremely rare. They are always attended by extensive destruction of the neighbouring soft parts, and are likely to be followed by purulent inflammation, sloughing, etc. Symptoms of a like nature, though less severe, may be excited by the injection of stimulating remedies, for curative purposes, through the Eustachian tube. Caustic solutions, used as nasal douches, may pass into the tympanum, and cause severe inflammation.

Injuries belonging to the second class—viz., those caused by blows or falls on the head, and involving fracture or fissures of the base of the skull—generally cause more or less profuse hæmorrhage, the source of the blood being either the lateral or petrosal sinuses, and in some cases the middle meningeal artery. Escape of cerebro-spinal fluid is another symptom which may continue for several days. The fluid may be either purely serous in appearance, or more or less deeply tinged with blood. It must be borne in mind that a serous discharge, coming on some days after an injury, and when hæmorrhage has ceased, is not necessarily indicative of escape of cerebro-spinal fluid; it may be secreted by the tympanic mucous membrane. Moreover, the discharge, by the meatus, of cerebro-spinal fluid may occur in the absence of fracture of the base of the skull, inasmuch as this fluid passes into the labyrinth, and may escape therefrom when the inner wall of the tympanum is the seat of fracture. Cases in which serous fluid escapes from the ears after injury are by no means rare, and the quantity may be very considerable; thus three or four ounces and even more have been discharged within an hour. The symptom may continue for several days, and then gradually cease. Fissures involving the base of the skull are by no means necessarily fatal.

The various questions connected with watery discharges from the ear after severe injuries to the head, are fully discussed in Sir P. Hewett's Article in Holmes's *System of Surgery.** It is there laid down that the escape of cerebro-spinal fluid "implies a fracture cutting across the meatus internus and communicating with the tympanum, a laceration of the tubular sheath of the cerebral membranes surrounding the seventh pair of nerves within this meatus, and a laceration of the membrana tympani." Those cases, however, in which the fracture does not involve the internal meatus, though passing across the internal and middle ear, require a different explanation. The watery discharge has then been thought to be derived from the perilymph of the labyrinth; but its quantity in some cases would seem too great to be furnished from this source. Profuse watery discharge has also been noticed after a severe injury of the head, in cases in which it was proved that there was no fracture involving either the internal or the middle ear, and no communication whatsoever between these cavities. In such cases, the inflamed lining membrane of the middle ear is regarded as the source of the fluid discharge, which makes its appearance some hours after the occurrence of the injury.

According to Sir P. Hewett, cases of watery discharge from the ear after injury may be divided into three classes.

In the first, the fluid is plentiful, and of a decidedly watery character immediately after the injury—the discharge is due to escape of cerebro-spinal fluid, which can only take place through a fracture of the petrous bone, implicating the internal auditory canal and its membranes.

---

* Vol. i. p. 593.

In the second class, there is copious and prolonged bleeding from the ear, followed by a watery discharge. This sequence of events indicates fracture of the petrous bone; but it cannot be said that the fracture follows any particular course.

In the third class of cases the discharge at first consists of blood alone; this is followed by a watery discharge, varying in quantity and as to the time of its appearance. "It may be present within a very few hours after the accident; it may be profuse within a very few hours of its appearance." In such cases the diagnosis is doubtful. The discharge of blood is not of such a character as positively to indicate a fracture of the petrous bone, and it is well known that a watery discharge may occur within a few hours after the accident, that its quantity may even be profuse, and yet there may be no fracture.

Urbantschitsch points out that cerebro-spinal fluid is distinguishable from serous exudation by the fact that it contains some reducing constituent (pyrocatechin, according to Halliburton), and very little albumen. It does not spontaneously coagulate.

In connection with fissures caused by injury, it would seem desirable to refer to those openings in the bony walls of the tympanum which are the result of defective ossification or of absorption due to pressure. The openings referred to are most commonly found in the roof and the floor of the cavity, and in the layer of bone between it and the carotid canal.

The plate of bone forming the roof of the tympanum, and particularly that portion of it which is above the malleo-incudal joint, and covers the recessus epitympanicus, is often so thin as to be transparent, and it is here that openings or dehiscences are most often met with. Through such minute gaps the lining membrane of the cavity comes into contact with the dura mater, and diseased processes in the middle ear may be easily propagated to the brain. In children, the condition of the petrosquamous suture facilitates communication between the two cavities. The fissure between these two portions of the bone is occupied by a prolongation of the dura mater containing vessels and connective tissue, and closely connected with the mucous membrane of the tympanum. Inflammation may thus easily spread from one cavity to the other.

The openings in the tympanic roof in adult life are in most cases the evidences of atrophy due to pressure by the convolutions of the brain. Bürkner,* who has investigated this subject, states that in the macerated skull they are often found associated with deep digital impressions and tenuity of the orbital plates. He points out that besides the spots already mentioned, dehiscences are sometimes present in the walls of the aqueduct of Fallopius, in the jugular fossa, in the mastoid process, and in the squamous portion. The formation of dehiscences in the roof of the tympanum is favoured by excessive development of the cavity and thinness of the osseous boundaries. Other investigations † show that dehiscences occur in about 7 per cent. of all cases, and exclusively in the brachycephalic skulls.

Openings or dehiscences in the floor of the cavity may result either from defective development or from pressure. This portion is membranous until the fifth month of embryonic life, and in some cases this condition persists for several years after birth. Dehiscences, the result of atrophy, are sometimes associated with unusual size of the jugular fossa, which encroaches upon the cavity of the tympanum.

The osseous lamella separating the carotid canal from the tympanum is sometimes very thin, and openings occasionally exist. These are for the most part the result of defective development, but they may be due to caries. In one recorded case, a groove existed in place of a canal.

Hæmorrhage in the Tympanum most often results from injuries; but it may occur in connection with various morbid conditions. When the membrane is intact, the injury is almost always of an indirect kind, *e.g.*, a fall or blow on the chin, violent coughing (as in whooping-cough), sneezing, straining efforts at vomiting, or forcible injection of air through the Eustachian tube. After death by strangulation, blood is often found effused in the tympanum. The diseases with which a similar condition is sometimes associated are—Bright's disease, diphtheria, leucocythæmia, scurvy, and hæmophilia. During menstruation, and in advanced stages of pregnancy, effusion of blood has been known to take place into the tympanum.

---

* *Arch. f. Ohrenheilkunde*, vol. xiii. p. 185.

† *Ibid.*, vol. xxviii. p. 169.

Embolism of the tympanic arteries is another condition which may cause hæmorrhage within the tympanum, and this symptom may arise in the course of endocarditis. The blood is effused both within the substance of the mucous membrane and on the surface.* The emboli occupy the spots at which lateral branches are given off, and consist of finely granular masses, probably composed of micro-organisms, which are found in abundance in the effused blood. In cases of sudden deafness occurring during pyæmia, minute sharply-defined patches of effused blood, purple or black in colour, have been found in the mucous membrane. Other local processes—*e.g.*, ulceration, caries, and necrosis of the walls of the cavity—may give rise to varying degrees of hæmorrhage.

When the membrane is intact, hæmorrhage within the tympanum will cause more or less marked subjective symptoms, as deafness, noises in the ear, a sensation of fulness, and sometimes pain and vertigo. The objective symptoms vary with the amount effused and the previous condition of the membrane. When the part was previously normal and the hæmorrhage has been somewhat copious, the membrane appears bluish-red or even black, devoid of lustre, and projecting, especially at its posterior and upper part, into the meatus. The handle of the malleus appears more distinct than usual against the darkened membrane. Such appearances are, of course, absent when the membrane is opaque and thickened. Râles are heard when air is forced into the tympanum; bone-conduction is increased on the affected side, while Rinne's test gives a negative result. In favourable cases, absorption gradually takes place; the membrane becomes yellowish-red, and in the course of three or four weeks assumes its normal tint. Suppuration, followed by perforation of the membrane, very rarely occurs. As a result of injury, such as a blow on the side of the head, the hæmorrhage may be confined to the attic; but only when that portion has been shut off by adhesions from the remainder of the tympanic cavity.

Treatment.—This consists in protecting the affected ear and keeping the patient at rest. A low non-stimulating diet should be prescribed, and purgatives are generally useful. After several days have elapsed, the air-douche may be employed to hasten absorption. It is very seldom necessary to make an opening in the membrane, and unless there be great tension and violent pain, it is better to refrain from any such operation. If, however, the latter be deemed necessary, it should be performed under strict antiseptic precautions, otherwise there is great risk of setting up purulent inflammation.

---

* *Arch. f. Ohrenheilkunde*, vol. xiv. p. 73.

Hæmorrhage into the Tympanum with Perforation or Rupture of the Membrane.—When an injury which causes rupture of the membrane gives rise at the same time to hæmorrhage within the cavity, more or less blood will escape from the meatus. A discharge of blood from the external meatus is also a symptom of hæmorrhagic tympanitis, of new formations in the canal or in the middle ear, of polypoid growths, of ulceration within the cavity, and of caries of its walls. Foreign bodies thrust through the membrane, attempts at their removal, and operations upon polypoid growths, are other causes of hæmorrhage from the tympanum. Except in cases of hæmophilia, the discharge is seldom profuse. In the operation of paracentesis, the commencement of the internal jugular vein has been occasionally wounded (see page 352). Hæmorrhage from the ear after injury is regarded as one of the most valuable diagnostic signs of a fracture of the base of the skull (see page 638). As a positive symptom, however, of this injury, the bleeding must be copious and must continue for some time. Hæmorrhage of this character is indicative of fracture of the base running through the petrous bone, and creating a communication between the cavity of the tympanum and some of the large vascular channels which surround the bone, or with extravasated blood within the cranium itself.

It must, however, be noticed that fractures of the temporal bone frequently occur without causing hæmorrhage from the ear. In such cases, either the fracture does not involve the tympanum, or the membrane remains intact, so that the blood cannot escape. Sir P. Hewett has recorded seventeen cases of fractured base, without bleeding from the ear: in twelve of these, the tympanum was not involved; in the remaining five, the tympanum was fractured, but the membrana tympani was not ruptured. The prognosis must always be guarded, for the first symptoms of serious import may be those of purulent meningitis, rapidly becoming fatal. The sound condition of the tympanic membrane does not of necessity justify a favourable prognosis.

In cases of fractured base, with ruptured tympanic membrane, when the fracture communicates with one of the venous cerebral sinuses and the walls of the tympanum, the hæmorrhage may be very profuse. In a case of injury to the occiput, recorded by Mr. Holden, the escape of venous blood from the meatus was like the flow from the spout of a teapot. The fracture was considered to involve the lateral sinus. In another case, an incision through the lower part of the membrana tympani penetrated the floor of the cavity (through a dehiscence) and injured the jugular vein. Injuries involving the carotid canal and the middle meningeal artery may likewise cause hæmorrhage from the meatus.

If hæmorrhage takes place into the tympanum, without rupture of the membrane, the blood will find its way through the Eustachian tube, so that there may be bleeding from the nose or from the mouth, or subsequent vomiting of blood. And even when a rupture of the membrane exists, escape of blood through the Eustachian tube may also take place; so that in some cases of fractured petrous bone, bleeding occurs from the ear, nose, and mouth at the same time, the blood thus discharged from several openings being derived from the same source.

As already mentioned, in cases of injury, in which escape of blood from the ear is an early symptom, the bleeding, after a few days, is often replaced by a pale straw-coloured fluid. A case in which both tympanic membranes were ruptured, and the hæmorrhage was followed by discharge of a yellow fluid, is recorded by Dr. Ray,* of Louisville, U.S.

Destruction of the tympanic walls by caries or necrosis may implicate one or other of the large vascular channels connected with the petrous bone, viz., the carotid artery, the jugular vein, and the lateral sinus. In a case reported by Drs. Moos and Steinbrügge,† there was caries of the petrous portion of the temporal bone, with facial paralysis and fatal hæmorrhage from the carotid artery. On examining the bone after death there was a deficiency in the external wall of the carotid canal, measuring 15mm. in breadth and 7mm. in height. The artery was bare to the whole extent of this opening, and corroded and perforated near the promontory. Hessler* has collected fourteen cases in which fatal hæmorrhage was the result of a similar lesion in the walls of the carotid artery. The latter may, however, be exposed, after carious destruction of the carotid canal, without being involved in the disease. Cases in which fatal hæmorrhage has been caused by destruction of the walls of the jugular vein, or of the sinuses connected with the temporal bone, are less common.

---

* *Archives of Otology*, vol. xv. p. 192.

† *Ibid.*, vol. xiii. p. 162.

Treatment.—When the hæmorrhage is slight in amount and is caused by polypoid or other growths, or by injury not involving the large vessels, it often ceases spontaneously. Should it continue, a plug of cotton-wool, impregnated with powdered alum or perchloride of iron, should be introduced into the meatus.

When large vessels are affected, more active measures will be required, though for venous hæmorrhage—*e.g.*, from the lateral sinus—plugging the meatus is the only available means of arresting the flow of blood. The sinus readily becomes occluded by the formation of a thrombus. When the blood comes from the internal carotid, ligature in the neck may not prove successful, inasmuch as the collateral circulation is readily established. In one case, Prof. Billroth tied the common carotid artery; but ten days afterwards the hæmorrhage recurred, and became so profuse as to induce the surgeon to tie the corresponding artery on the other side. Two days later the hæmorrhage recurred, and the patient died. Urbantschitsch points out that ligature of the carotid should be performed only if it be found that well-directed pressure upon the artery arrests the bleeding. Such pressure will, of course, have no effect upon hæmorrhage the result of lesions of the sinuses. The artery has been tied when the lateral sinus was the real source of the hæmorrhage.

---

* *Archiv f. Ohrenheilkunde*, vol. xviii. p. 1.

CHAPTER XXXVII.

OTALGIA.

Causes—Symptoms and Treatment.

Pain of a neuralgic character is sometimes felt in the external and middle portions of the ear, while careful examination fails to detect any evidences of inflammatory or other changes. In the large majority of cases, the pain is referred to the tympanum and deeper part of the meatus; the auricle is less commonly affected. Pain in the auricle is generally limited to some definite portion. On the external surface, it follows the distribution of the auriculo-temporal nerve, a branch of the inferior maxillary. On the inner surface, pain is felt along the filaments of the great auricular and the small occipital nerves, from the cervical plexus; and it is sometimes associated with an eruption of herpes zoster. In other cases the auricle is reddened and swollen during the attack. The sensory nerves of the tympanum are supplied by the fifth pair and the glosso-pharyngeal. In the tympanic plexus, a branch from the petrous ganglion of the latter nerve communicates with the great superficial petrosal, which is connected with Meckel's ganglion. The small nerve of the same name joins the otic ganglion, and a filament from the sympathetic unites the tympanic with the carotid plexus. Another filament from the petrous ganglion passes to the auricular branch of the pneumogastric. The numerous relations thus formed account for the radiating character of the pain, which is sometimes noticed.

Causes.—The most common cause of otalgia is a decayed tooth, and generally a lower molar, which may itself be quite free from pain. In these cases, the pain may extend to the neck, shoulder, and arm. Ulceration in the larynx, pharynx, and in the upper part of the œsophagus is often accompanied by pain in the ear; abscess and cancer of the tongue,* and thoracic aneurysms† sometimes produce the same symptom. Other less common causes of otalgia are exposure to cold, anæmia, neurasthenia, disorders of the sexual organs, irritative processes involving the Gasserian ganglion and the second and third divisions of the fifth nerve, caries of the bones, and tumours of the brain. Otalgia is sometimes due to the influence of malaria (see page 625), and is sometimes connected with syphilis. Evidences of periostitis, and of specific changes in the minute arteries of the tympanum, have been found in syphilitic subjects who had complained of otalgia.

In young children, pain in the ears is often due to teething. In such cases it is probably caused by extension of inflammation from the mouth and pharynx along the Eustachian tube. Reflex irritation may, however, take part in its production. The tympanum is supplied by the tympanic branches of the internal carotid, and by branches of the internal maxillary and stylomastoid arteries, from the external carotid trunk. Irritation from inflamed gums is communicated to the otic ganglion, and dilatation of the tympanic vessels results from inhibition of the vaso-motor nerves. If the process become severe, it may result in acute catarrh of the tympanum.

The pain in otalgia may be either intermittent or continuous; when due to the influence of malaria the attacks are distinctly periodical. In some cases the pain is not confined to the ear, but radiates to the neck and shoulders. It is sometimes accompanied by subjective auditory sensations and deafness, and by hyperæsthesia of the skin of the auricle and temple. The pain is apt to be increased by loud noises and by movements of the head. Excessive and prolonged irritation of the auditory nerve may indeed be the exciting cause of pain in the ear. Thus Urbantschitsch records a case in which bilateral otalgia, which had troubled the patient for eighteen months, was traceable to piano-playing in a room in which resonance was very marked. The pain was decidedly aggravated by loud sounds, and was relieved by galvanism.

---

* Hilton, *Lancet*, 1860, vol. ii. p. 257.

† Gull, *Medical Times and Gazette*, 1864, vol. i. p. 34.

It must, of course, be borne in mind that otalgia may co-exist with carious teeth without being in any way dependent upon them. In all cases the ears must be carefully examined, and, if no disease can be detected, the condition of the teeth, larynx, and throat should next be ascertained.

In rare cases, the mastoid region is the seat of violent pain, coming on in paroxysms, but unaccompanied by any signs of inflammation or by tenderness on pressure. The tympanic membrane may be normal in appearance, or there may be cicatrices or quiescent perforations. In such cases the cause of the pain is altogether uncertain. It would be necessary to enquire into the general health and previous history of the patient, and especially to ascertain the possibility of a syphilitic origin. In one case of obstinate mastoid neuralgia, with occasional pruritus of the meatus, the patient was found to be suffering from diabetes.

Treatment.—This must depend upon the cause and duration of the complaint. Decayed and aching teeth must be extracted or otherwise treated; anæmia and debility will require tonics, such as iron and quinine. The latter drug will be useful when the otalgia is accompanied by symptoms of tic douloureux, and especially in cases with a history of exposure to malaria. Gelsemium, arsenic, salicylate of sodium, and bromide of potassium or ammonium sometimes do good in these cases. In syphilitic subjects, full doses of iodide of potassium will, of course, be indicated. This remedy sometimes relieves the pain in non-syphilitic cases. When the attack is very severe, morphine may be given either internally or by subcutaneous injection.

In chronic cases, besides the remedies already mentioned, turpentine, belladonna, oxide of zinc, and antipyrin have been recommended by various authorities. Weber-Liel has seen good results from oil of turpentine, in doses of ♏xv.—xx. Belladonna is used either in the form of ointment applied to the mastoid process, or internally, in doses of ♏v. of the tincture. Atropin, in doses of five drops of a 1 per cent. solution several times daily, has been found efficacious. Antipyrin has been used in doses of five grains three or four times a day. The local application of veratrine in the form of ointment is worthy of a trial. The following combination has also been recommended: menthol and camphor, of each, one part;

liquid vaseline, twenty parts. Galvanism is occasionally useful when all other means have failed. The positive pole is placed on the ear; the negative, on the back of the neck. The induction current is not recommended, on account of the cutaneous hyperæsthesia which often co-exists. Relief may sometimes be obtained by the application of a blister (see page 349) to the mastoid process. In cases in which the pain is not confined to the deep parts of the ear, but affects the entire aural region, and is increased by pressure beneath the tragus, massage has been followed by great relief, and complete subsidence of the discomfort in the course of a few days. For intermittent otalgia, Urbantschitsch recommends, besides quinine, the inhalation of a few minims of amyl nitrite.

CHAPTER XXXVIII.

THE ANATOMY AND PHYSIOLOGY OF THE INTERNAL EAR.

The Auditory Nerve and the Divisions of the Labyrinth—The Vestibule—The Semicircular Canals—The Cochlea—The Membranous Semicircular Canals—The Cristæ Acusticæ—Otoliths—The Cochlear Nerves—The Scala Media—Corti's Membrane and Organ—The Membrana Basilaris—The Auditory Teeth—Corti's Pillars and Cells—Connections of Cells with Nerves—Reissner's Membrane—Blood-vessels of the Internal Ear—Origin of the Auditory Nerve—Its Connections and Divisions—The Physiology of the Labyrinth—Functions of the Utricle, Saccule, and Semicircular Canals—Flourens' Experiments and their Results—Functions of the Cochlea—The Auditory Area.

The Auditory Nerve, on leaving the base of the skull, enters the petrous portion of the temporal bone, and passes into a complicated organ, the osseous labyrinth. When this is opened, the internal surface is found to be covered by a connective-tissue membrane, the periosteum, which immediately incloses the perilymph. The latter covers the membranous labyrinth, which has for the most part the shape of its osseous capsule. The osseous labyrinth is divided into three portions: the semicircular canals, the vestibule, and the cochlea. The first of these contains the membranous canals; the second, the utricle or *sacculus ellipticus*, and the *sacculus rotundus;* while the third contains the windings of the *ductus cochlearis.* All these three divisions of the membranous labyrinth communicate with each other: the semicircular canals and the utricle directly; the sacculus and the ductus cochlearis through the *canalis reuniens;* the utricle and the saccule through the *saccus endo-lymphaticus*, which, being connected by a short limb with each sac, passes through the aquæductus vestibuli to the dura mater, where it ends in a blind pouch lying against the posterior surface of the petrous bone. A communication between the subarachnoid spaces of the brain and spinal cord and the perilymphatic space of the cochlea is provided by the *aquæductus cochleæ*, while the arachnoid sheath of the auditory nerve furnishes a passage for the endolymph. The perilymph which surrounds the saccule is in contact with the membrane of the fenestra ovalis, and receives from it the vibrations of the air in the tympanic cavity. A lax series of connective bands traverses the fluid, and keeps the membranous parts in their place.

The Vestibule is irregular in shape, and measures about one-fifth of an inch from above downwards and from behind forwards; from its outer to its inner wall the distance is about one-tenth of an inch. The cochlea opens into it in front by a single opening; and the semicircular canals, by five orifices behind. On its outer wall is the *fenestra ovalis;* and above this, the anterior opening of the external semicircular canal. Its inner wall presents several minute apertures, through which a portion of the auditory nerve enters from the internal auditory canal. At the posterior part of this wall is the opening of the *aquæductus vestibuli.*

The openings on the inner wall of the vestibule are about twenty in number, and are collected into four groups, each group constituting a *macula cribrosa.* Through the upper *macula,* the nerves pass to the utricle and to the ampullæ of the superior and external semicircular canals. The other *maculæ* give passage to the nerves for the saccule and for the posterior semicircular canal, and to a small branch of the cochlear nerve. At the anterior portion of the vestibule is the commencement of the *scala vestibuli* of the cochlea.

The outer wall of the vestibule, which separates it from the cavity of the tympanum, is perforated by the fenestra ovalis, but this aperture is so completely closed by the base of the stapes that the inner surface appears quite even. At the fore part of the inner wall is a small round pit, the *fovea hemispherica,* which is limited behind by a vertical ridge, called the *crista vestibuli.* Partly in the roof and partly in the inner wall is an oval depression, the *fovea hemielliptica,* the inner part of which is separated by the crest from the hemispherical fossa.

The Semicircular Canals are three osseous tubes, situated above and behind the vestibule, into which they open by five apertures, the contiguous ends of two of the canals being joined together. They are unequal in length, but each is bent so as to form about two-thirds of a circle, and each canal has at one end a slightly dilated part, or *ampulla*.

The canals differ from each other in length, direction, and position with regard to the vestibule, and each canal lies in a different plane. The *superior canal* is vertical and anterior, and lies across the petrous bone. It forms about two-thirds of a circle, and its extremities are more divergent than those of the others. It rises higher than any other part of the labyrinth, and its place is indicated by a smooth elevation on the anterior surface of the petrous bone. The *ampulla* is on the outer extremity; the opposite end opens by a common extremity with the posterior semicircular canal into the back part of the vestibule. It is to be noticed that the superior canal of one side lies in a plane parallel to that of the posterior canal of the other. The *posterior semicircular canal* is vertical and longitudinal in direction, and runs parallel to the posterior surface of the petrous bone, and therefore at right angles to the former. It is the longest of the three tubes; its *ampulla* is at its lower extremity, and its opposite end terminates as above described. The *external semicircular canal* is inferior and shorter than either of the others; its arch is directed horizontally outwards, and it opens by two distinct orifices into the upper and back part of the vestibule. The external canals of the two sides lie in the same plane.

The length of the superior vertical canal along its convex border is about four-fifths of an inch; that of the posterior is about eleven-twelfths of an inch; while the external or horizontal measures only one-fifth of an inch. The diameter varies from one-twentieth to one-fifteenth of an inch. As age advances, the semicircular canals increase in length, and also very slightly in width.

The Cochlea is so named from its resemblance to a common snail-shell. It lies in front of the vestibule, and is placed almost horizontally; its apex is directed forwards and outwards, its base is near the bottom of the internal meatus, and is marked by a depression with a spiral arrangement of pores for the reception of the cochlear division of the auditory nerve. From its base to its apex extends a conical axis or central pillar, the *modiolus* or *columella*, which is perforated by many channels, through which nervous filaments pass in regular succession to the spiral cochlear canal which winds round the axis. This canal is about an inch-and-a-half in length, and diminishes gradually in size from the base to the apex, where it ends in a cul-de-sac. At its commencement it is about one-tenth of an inch in diameter, but scarcely half that size at its termination. At its base, the canal presents *three openings:* one of these communicates with the vestibule; another is the *fenestra rotunda*, shut off from the tympanum by a membrane; while the third is the opening of the *aquæductus cochleæ*, which leads to the jugular fossa and transmits a small vein. The spiral canal makes about two turns and a half, of which the first takes the widest sweep, so as to encircle most of the second turn. The first turn bulges somewhat into the tympanum, and causes the round elevation, named *the promontory*, on the inner wall of that cavity.

The spiral canal of the cochlea is divided into two parts or passages by a thin osseo-membranous lamina, stretching between its modiolar and peripheral wall, and on which the nervous filaments are distributed. This lamina is made up of two parts: one, a brittle osseous process, extends from the modiolus; the other part is membranous, and connects the outer thin edge of the osseous zone to the outer wall of the canal. In this way a complete septum is formed between the vestibular and tympanic openings of the cochlea, and the two passages into which the spiral lamina divides the canal correspond respectively to those chambers. The upper passage, towards the apex of the cochlea, is termed the *scala vestibuli;* the lower, towards its base, the *scala tympani.* In the last half-turn of the canal the spiral lamina ceases, and the two scalæ communicate by a common orifice called the *helicotrema.* The axis terminates in a delicate lamella at about half a turn from the dome-like summit or cupola. This lamella, as viewed from below, resembles a funnel open on the side, while above it blends with the cupola.

The cavity of the osseous labyrinth is occupied by a limpid fluid, the *perilymph,* so called from its surrounding, in the vestibule and semicircular canals, a hollow membranous apparatus, the membranous labyrinth, which contains a similar fluid, the *endolymph.*

The Membranous Semicircular Canals are separated by the perilymph from their osseous case; that part of each which is towards the concavity of the semicircle is free, but the opposite portion is fixed to the wall of the bony canal by blood-vessels and connective tissue. These canals have the same names, shape, and arrangement as the osseous canals which inclose them; but are only from one-third to one-fifth of the diameter of the latter. As the osseous canals open into the vestibule, so the membranous ones open at both extremities into the utriculus, and near this latter structure each tube presents a slightly dilated part, called the *ampulla*. These portions are closely adapted to the surrounding bone, and contain in their interior the terminal ramifications of a portion of the vestibular branch of the auditory nerve. The remaining part of this division of the nerve passes to the utricle and saccule of the vestibule, where it is distributed to certain structures, the *maculæ acusticæ*. The other portion of the membranous labyrinth, the *cochlea*, contains the terminations of the second branch of the auditory nerve, which are to be found in the organ of Corti. The internal ear may therefore be said to present six parts characterised by peculiar nerve-endings.

The membranous semicircular canals and the other structures of the labyrinth are filled and kept tense by a watery fluid, the endolymph. In the recent condition, the walls of these structures are quite transparent; though of great delicacy, they are composed of several layers: (1) an external fibrous layer, which contains the vessels (*membrana propria*); (2) a clear, membranous structure (basal membrane), lined by (3) pavement epithelium. Close to the utricular orifices of the ampullæ, and on the surface which projects from the convex border of the arch, all these layers become thickened, and form a prominence in the cavity, resembling a comb, and distinguishable to the naked eye by its yellow colour: the term *crista acustica* is applied to each of these spots. At certain parts of their walls, the utricle and saccule present similar changes; in each of these cavities there are two enlargements, sharply circumscribed, roundish in form and whitish in colour. The fibres of the vestibular branch of the auditory nerve can be traced to these spots in the ampullæ, utricle, and saccule, and are here found to terminate in a peculiar manner.

The *cristæ acusticæ* are traversed by nerve-fibres which pass to the borders of the ridges, over which the epithelium is of an elongated columnar form, and is surmounted by long, conical, gradually tapering filaments (auditory hairs), which project stiffly into the cavity, and are about 0·03mm. in length. A single hair projects from each epithelial cell; but near their bases, these hairs are apt to split up into minute fibrils. The epithelial cells do not extend down to the basement membrane; beneath and between them there are other cells, which are probably sustentacular in function, and are not furnished with hairs. The epithelial cells proper often contain yellowish pigment-granules, which give a peculiar tint to the *maculæ* and *cristæ*. The cells are so arranged that almost every hair-cell is surrounded by five supporting cells.

The histological peculiarities, just described, of the epithelium of the *cristæ*, are repeated in the epithelium of the *maculæ acusticæ*, and the terminations of both branches of the auditory nerve are alike in the fact that their cilia are enveloped in a semi-fluid, tenacious substance, which, after treatment with certain reagents, stiffens so as to resemble a membrane, which has received the name of *cupula terminalis*. There is only this important difference between the two parts, that the mucous stratum of the *maculæ acusticæ*, on its free surface which is washed by the endolymph, is strewn over with many small concrements, of an inorganic nature, the so-called "otoliths," which are either wanting, or very sparsely distributed, in the ampullæ and semicircular canals. The otoliths are composed partly of many small amorphous and crystalline bodies, and partly of large bunches of crystals of carbonate of lime. The chalk-like tint of the *maculæ acusticæ* is due to these bodies.

With regard to the relations of the nerves to the *cristæ* and *maculæ acusticæ*, there is the same obscurity as that in which the question of the peripheral termination of other nerves is involved. The assertion is sometimes made that the axis-cylinders, devoid of medulla, or the axis-fibrils, pass directly into the substance of the hair-cells; but a very intimate connection, without fusion, is more often described. At any rate all the histological facts at present known justify the supposition that the modified epithelial forms of the bristle-cells constitute the proper terminal apparatus of the auditory nerve in the vestibule.

The Cochlear Branch of the auditory nerve contains a large number of medullary fibres. Connected with it is "Corti's organ," which includes not only the nervous terminal apparatus, but, as in the vestibule, hair-cells, which receive the last prolongations of the auditory nerve. It is unnecessary to describe all the investigations that have been made into the histological structure of Corti's organ; it is sufficient to mention those points which have a special physiological significance.

The canal of the cochlea is divided into two distinct spaces, separated by bony and membranous septa. The principal septum is the *lamina spiralis* (Fig. 125, *sp.l*), which is composed of a portion, the *zona ossea*, proceeding from the modiolus, and a membranous layer, the *zona membranacea*, *membrana basilaris* (Fig. 125, *b.m*), attached to the external border of the latter, and to the outer wall of the cochlea. Formerly this septum was the only one that was recognised; and the portion of the canal above it was called the *scala vestibuli*, the portion below it the *scala tympani* (Fig. 125, *s.v* and *s.t*). Both these contain perilymph. There is, however, a third membranous septum, first

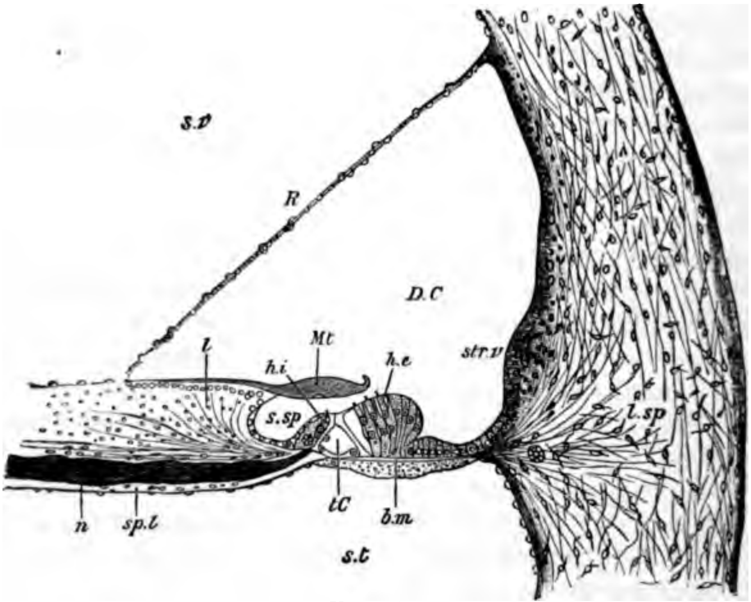


FIG. 125.

SECTION ACROSS THE BASAL TURN OF THE HUMAN COCHLEA. × 100. (Retzius, from Quain's *Anatomy*.)

D.C. ductus cochleæ; *s.v.* scala vestibuli; *s.t*, scala tympani; *R*, membrana Reissnerii: *Mt.* membrana tectoria; *b.m*, membrana basilaris; *str.v*, stria vascularis; *l.sp*, ligamentum spirale · *l*, limbus; *s.sp*, sulcus spiralis; *t.C*, tunnel of Corti; *n*, nerve-fibres; *sp.l.* spiral lamina.

correctly described by Reissner, and named by Kölliker, Reissner's membrane (Fig. 125, *R*), which, springing from the upper surface of the *zona ossea*, close to its outer border, stretches obliquely towards the outer wall of the cochlea, cutting off a third canal between the scala vestibuli and scala tympani, termed the *canalis* or *ductus cochlearis*, or the *scala media* (Fig. 125, *D.C*). This canal is filled with endolymph, and contains Corti's organ (or the *papilla spiralis*), with the terminations of the cochlear nerves; it communicates with the *sacculus* through the *canalis reuniens*.

The osseous portion of the *lamina spiralis* is traversed in its interior by a system of anastomosing canals, which run together to a cleft situated close to its outer border, and dividing it into two laminæ. In these canals and in the marginal cleft run the cochlear nerves radiating from the modiolus, which they enter by a number of fine openings arranged in a spiral, the *perforate spiral tract.* The spiral shape is due to the linear extension of the cochlear tube, and of these nerves, which have increased in number while constrained in capacity of linear extension. The lamina spiralis is simply the projecting plate around the nerves as they pass to their distribution in the cochlear canal (Macalister). The perilymph enters through the *scala vestibuli*, and passes down the *helicotrema* to the *scala tympani*, whence its escape is prevented by the *membrana tympani secundaria.*

In the cochlea the acoustic area is continued as a stripe along the wall of the cochlear canal. The canal itself is roughly triangular on section; one side, the most vascular, is attached to the outer convex whorl; the second (Reissner's membrane) extends from this to form the floor of the scala vestibuli; while the third, stretching to the tympanic edge of the *lamina spiralis*, forms the roof of the scala tympani. On the osseous portion, the projecting *crista spiralis* is prolonged above and below, and forms a notch, the *sulcus spiralis internus* (Fig. 125, *s.sp*). The upper or vestibular lip is covered by a cuticular structure, **Corti's Membrane,** while the lower or tympanic lip passes into the *membrana basilaris*, which extends over the membranous *lamina spiralis*, and supports the peculiar epithelial structure known as **Corti's Organ** (Fig. 126).

In the *lamina spiralis ossea* the auditory nerve-fibres run to the *zona perforata* in the *labium tympanicum*, whence passing through foramina in the basilar membrane, and devoid of their medullary cylinders, they reach Corti's organ and the neuro-epithelial cells. On its vestibular edge, the *crista spiralis* is furnished with radiating ridge-like elevations, termed "auditory teeth," the number of which is estimated at about 2,500. Besides having a connective tissue stroma and a periosteal layer, the *crista spiralis*, which contains many vessels, is likewise invested by a glassy stratum in which no cells can be discovered.

The *membrana basilaris* extends from the *labium tympanicum* of the *crista spiralis* to the *ligamentum spirale*, an inward prolongation of the lining periosteum and subperiosteal tissue. Rising from its surface is the **Organ of Corti** (Fig. 126), composed of highly specialised structures. Its central part is formed by two sets of stiff rod-like bodies, the inner and outer *rods of Corti*, which converge and meet above, so as to form a series of arches along the whole extent of the cochlear canal.

"On the inner side of the inner series of rods is a row of epithelial cells, which are surmounted by a brush of fine, short, stiff hairlets; and external to the outer rods are three or four successive rows of similar but more elongated cells. These cells are termed respectively the *inner* and *outer* hair-cells (Fig. 126). The hairlets of the outer hair-cells project through apertures in a curiously-formed cuticular membrane termed the *reticular lamina*, which covers the organ of Corti like a wire net. The hairlets of the inner hair-cells are one and a half times as long as those on the outer hair-cells."—(Quain.)

Certain other structures, known as the cells of Deiters (Fig. 126), are found beneath the outer hair-cells. These, which are of a cylindrico-conical shape, rest by their bases on the basilar membrane, and each one incloses in its substance a cuticular filament which is fixed below to that membrane. They are about twice as long as the adjacent hair-cells, and have a more oblique direction, and they also differ in shape and appearance. The hair-cells are for the most part clear and transparent, whereas Deiters' cells, except at their extremities, are cloudy and granular. The filament contained in each cell is prolonged to the tapering apex, between the hair-cells and closely attached to one of them, till it blends with the reticular lamina. Other cells, beyond the hair-cell region, are known as "supporting cells" (Hensen).

Corti's membrane, the *membrana tectoria* (Figs. 125 and 126), extends from the tympanal commencement of Reissner's membrane to the last series of the external rods. The substance of the membrane is stratified, but quite homogeneous; the tissue is a cuticular formation, having its origin in the epithelium of the *limbus laminæ spiralis.*

The physiological importance of Corti's cells and of their hair-like prolongations becomes the more intelligible when they are compared with the *maculæ* and *cristæ acusticæ*, and on considering their intimate connection with the axis-cylinders of the nerves in close contact with them. The cells of Corti, with their projecting hairs, may be assumed to be the terminal apparatus of the cochlear nerves. The connection has not been absolutely demonstrated; no statements have been made with regard to the relations of the *outer* cells of Corti to the terminal nervous fibrils; it is alleged by Lavdowski that the middle portion of each *inner* hair-cell is penetrated by an axis-fibril. According to Retzius, the number of the inner hair-cells, which are arranged in one row, reaches in the human subject 3,500; that of the outer, which are arranged in three or four rows, may be estimated at 12,000. The principal trunk of the cochlear nerve is to be found in the axis or modiolus of the cochlea. The bundles of fibres given off from it penetrate the anastomosing clefts in the laminæ

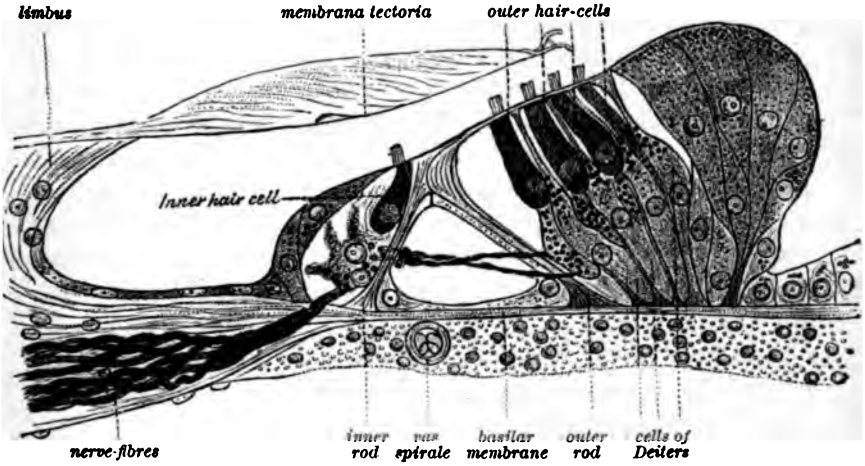


Fig. 126.

Section through the Organ of Corti of the Middle Turn of the Human Cochlea, highly magnified. (Retzius, from Quain's *Anatomy*.)

ossea along its whole length, and form therein a close plexus, which runs towards the outer border of the osseous band. Not far from this border many closely packed, small, bipolar ganglion-cells are inserted between the fibrils, each ganglion being probably traversed by a primitive nerve-fibre. On leaving the ganglia, the nerve-fibres at first constitute a network, but afterwards they run, parallel to each other, to the border of the *lamina ossea,* then pass through openings in the *habenula perforata* to the cochlear canal, and appear as fine varicose fibrils devoid of a medullary sheath, and resembling the terminations of the vestibular nerves in the epithelium of the *cristæ acusticæ*, and like portions of the olfactory nerve in the olfactory mucous membrane. Some of the fibres enter the epithelium in the region of the inner hair-cells (Fig. 126), amongst the bases of which one set appear to end, while others are continued as fine threads between the inner rods. Other fibres pass across the tunnel of Corti (Fig 125 *t.C*), between the rods, and enter the region of the outer hair-cells.

Reissner's membrane, or the vestibular wall of the ductus cochlearis, begins at the limbus of the osseous spiral lamina, and ends at the vestibular border of the outer wall of the duct. It consists of an extremely delicate connective-tissue layer either structureless or faintly striated; its vestibular surface is covered by a simple layer of endothelium, with a few spindle-shaped cells, sometimes containing pigment; while its tympanal surface, which looks towards the cavity of the ductus cochlearis, is lined by polygonal flattened cells. Reissner's membrane is curved, and bulges into the scala vestibuli, the curvature being the result of unequal pressure on the two sides.

Blood-Vessels of the Internal Ear.—The internal auditory *artery* is a branch of the basilar; it passes with the seventh pair of nerves into the internal meatus, and divides into a vestibular and cochlear branch. The latter breaks up into several small twigs, which pass through the openings in the tractus spiralis, and between the layers of the spiral lamina, and are finally distributed to the structures of the cochlea. The largest branch runs in the central canal of the cochlea. The artery to the vestibule divides into small branches, which pass through the posterior wall of the vestibule, and are distributed to the structures it contains and to the semicircular canals. Each of the latter receives two branches, one at its ampullary, and the other at its non-ampullary extremity; these anastomose with each other on the curvatures of the canals. The labyrinth also receives a few branches from the stylo-mastoid artery.

The *veins* have the same names as the arteries, and unite at the bottom of the internal meatus to form the commencement of the internal auditory vein, which opens into the superior petrosal sinus. It is doubtful whether any veins pass through the aquæductus vestibuli and cochleæ. Nothing can be definitely stated with regard to the lymphatics of the internal ear.

The Origin of the Auditory Nerve.—The auditory nerve arises by two roots, an external and an internal; these embrace the restiform body. The former is continuous with the cochlear nerve, and is the true nerve of hearing; the latter becomes the vestibular nerve, and is concerned in the maintenance of equilibrium. The nuclei are placed in the floor of the fourth ventricle, in the anterior part of the bulb, in front and to the side of the twelfth nerve. There is also an accessory nucleus, in an angular interspace between the other two. From this last, the external root is mainly derived. The fibres of the internal root appear to terminate in the chief nuclei; but some of them pass directly to the cerebellum. The two roots unite at the ventral border of the restiform body; and the nerve, thus formed, passes into the internal auditory meatus, where it divides into an anterior or upper and a posterior or lower branch. The former supplies the utricle and the ampullæ of the superior and external semicircular canals. The posterior branch supplies the saccule and the ampulla of the posterior semicircular canal. The remaining and larger portion of this branch passes into the central canal of the modiolus and the spiral lamina of the cochlea, and terminates in the organ of Corti.

The Physiology of the Labyrinth.—The labyrinth consists of a cavity, of very complicated shape, filled with fluid and surrounded by firm osseous walls. In the latter are two openings into the tympanum, of which one, the fenestra ovalis, in the vestibule, is closed by the base of the stapes; the other, the fenestra rotunda, opens into the cochlea, and is closed by the so-called *membrana tympani secundaria.* The osseous labyrinth contains the membranous structures and the terminations of the nerves. The sonorous vibrations reach the latter in the form of fluid undulations which are transmitted by the perilymph and endolymph of the labyrinth to the membranous structures and nerves. The displacement of the perilymph is greater for low than for high tones; the latter causing only the slightest movements in the fluid of the labyrinth. The normal and essential route for sonorous vibrations in the human subject is through the membrana tympani and the chain of bones; and the undulations of the fluid in the labyrinth caused by the movements of the base of the stapes in the fenestra ovalis, are the necessary excitants of auditory perception. All undulations, starting from the stapes, must be propagated in every direction, and traverse all parts of the labyrinth, that is to say, not only the vestibule and semicircular canals, but also the entire tube of the cochlea. They are transmitted from the vestibule along the scala vestibuli to the apex of the cochlea and the fluid in the scala tympani, and thence to the fenestra rotunda, as well as from the scala vestibuli, through the membrane of Reissner, to the fluid in the cochlear canal. It is owing to the elasticity of the membrane covering the fenestra rotunda, which yields to the pressure of the fluid of the labyrinth, that the base of the stapes is able to move. The membrane of the fenestra rotunda is incapable of receiving sonorous vibrations from the air in the tympanum and of conveying them to the cochlea.

The **functions of the various portions** of the internal ear will now be considered in detail. The *utricle* and the *saccule* are supposed to be adapted for the perception of noises, as distinguished from tones, the perception of which is thought to be the function of the cochlea. It would appear, however, from the results of experiments, that these parts have a share at least in the perception of tones; in some heteropods examined by Ranke, when certain notes were sounded, the auditory hairs were seen to vibrate freely, and to cause movements of the otoliths. Also in some experiments on the auditory apparatus of crabs, when certain definite sounds were produced, a certain number of hairs were thrown into vibrations. In these animals, the auditory structures provided with hairs correspond with the terminal apparatus in the *maculæ* and *cristæ acusticæ* of the vestibule and ampullæ.

The Semicircular Canals.—Opinions have differed very widely as to the functions of the semicircular canals. At one time they were regarded as the organ through which the direction of sounds was estimated; according to another theory, they are not concerned in the perception of sound, but are the organs through which co-ordinated movements are performed. As a matter of fact, such tubes containing fluid will conduct sonorous vibrations without loss of force; and vibrations, passing in the axes of the canals, must necessarily reach the nervous structures of the ampullæ. It is, however, pretty clear that the tubes are not designed to fulfil this purpose, for the vibrations can reach the ampullæ direct from the vestibule. The fact must not be overlooked that these portions of the canals are furnished with peculiar nervous structures, which are certainly adapted for the perception of sound. According to another view, the canals receive the vibrations which are conducted by the bones of the head, and convey them to the nervous expansions in the ampullæ. This theory of their functions was based upon their form and position; from whatever direction a sonorous vibration may traverse the cranial bones, it must impinge upon one or other of the canals almost or quite at a right angle. In the human subject, however, the bones constitute a very subordinate channel for the conduction of sonorous vibrations, and it is very unlikely that the functions of the canals should be thus restricted. Equally improbable is the theory which assigns to the canals the faculty of conveying impressions as to the direction of sounds; this latter is determined by the relation of the meatuses to the source of the stimulus to the auditory nerves.

The well-known experiments of Flourens prove that destruction of the membranous canals is attended by consequences unconnected with the sense of hearing, and that it causes symptoms generally described as vertigo. Admitting that the phenomena in question are due to the injury of the canals alone, it by no means follows that the nervous expansions in the *cristæ acusticæ* play no part in the reception of sonorous impressions.

In Flourens' experiments, which have been often repeated, one or more semicircular canals were divided on one or both sides, pigeons being usually selected for the operation. The results appeared in the form of movements, divisible into three classes. In the first, there were to-and-fro pendulum-like movements of the head, associated with intermittent oscillations of the eyes. In a second set the pigeon moved round in a circle; while in a third form the head was bowed down so as to come in contact

Vom
Th
can
th
a
and
of

tions which are transmitted by the perilymph and en ptoms.
the labyrinth to the membranous structures and ner fferent
placement of the perilymph is greater for low than is injured,
the latter causing only the slightest movements i ght; injury to
labyrinth. The normal and essential route for n movement;
in the human subject is through the membr the two kinds
chain of bones; and the undulations of the
caused by the movements of the base of th ing between the injuries
ovalis, are the necessary excitants of a ers think that the latter
undulations, starting from the stapes itement of the ampullary
every direction, and traverse all parts assert that they are caused
say, not only the vestibule and sem cerebellum. Those who
entire tube of the cochlea. They r to the manner in which the
bule along the scala vestibuli to t ing that the disordered move-
fluid in the scala tympani, and t in the stimuli which normally
well as from the scala vestibuli. the labyrinthine fluid, and vary
to the fluid in the cochlear ca d. According to another view,
the membrane covering the ation of the peripheral apparatus,
pressure of the fluid of the the cerebrum, causes the peculiar
able to move. The memb that the pressure of the endolymph
of receiving sonorous v of the nerves varies with the position
and of conveying then that movement of the endolymph
The functions of t movement of the latter part. The
now be considered produced must vary in the different
supposed to be ad movements, and hence it gives rise
tinguished from t the central organs, enabling animals
the function of t form correct ideas as to the position of
results of exper endolymph escapes, as the result of injury,
the perception the ampullary nerves, and the necessary
when certain discharge of their functions, is either lessened
vibrate freely shed; and the absence of any message from
some exper the animal incapable of estimating the
certain defi The resulting sensation of vertigo is the
were thro pendulum-like and other movements. Goltz
structures the semicircular canals as specific sense-organs
apparatu position of the head, and indirectly for the
ampulla whole body.
The of a somewhat similar character, is that main-
as to t He assumes that the disorder of equilibrium
were Cyon.

with the ground, and the beak was directed backwards. Vomiting is generally superadded to the other symptoms. The pendulum-like movements differ according as different canals are divided; thus, when the horizontal canal is injured, the movement is also horizontal to the left and right; injury to a vertical canal is followed by an up-and-down movement; and when both classes of canals are injured, the two kinds of movements are combined.

Opinions differ as to the relations existing between the injuries and the motor phenomena; some observers think that the latter are due to the altered conditions of excitement of the ampullary expansions of the nerves, while others assert that they are caused by injury to adjacent parts of the cerebellum. Those who advocate the first theory differ as to the manner in which the canals are affected, some supposing that the disordered movements are due to the decrease in the stimuli which normally originate in the influence of the labyrinthine fluid, and vary with the position of the head. According to another view, the injury produces fresh irritation of the peripheral apparatus, and this, being transmitted to the cerebrum, causes the peculiar movements. Goltz believes that the pressure of the endolymph upon the ampullary endings of the nerves varies with the position of the head; others suppose that movement of the endolymph is always associated with movement of the latter part. The mechanical irritation thus produced must vary in the different ampullæ with the cranial movements, and hence it gives rise to specific sensations in the central organs, enabling animals and human beings to form correct ideas as to the position of the head. When the endolymph escapes, as the result of injury, the normal stimulus to the ampullary nerves, and the necessary condition for the discharge of their functions, is either lessened or altogether abolished; and the absence of any message from the periphery renders the animal incapable of estimating the position of its head. The resulting sensation of vertigo is the final cause of the pendulum-like and other movements. Goltz therefore regards the semicircular canals as specific sense-organs for maintaining the position of the head, and indirectly for the equilibrium of the whole body.

Another view, of a somewhat similar character, is that maintained by Cyon. He assumes that the disorder of equilibrium is due to the vertigo, but he thinks that the latter is the result of the auditory sensations which are transmitted by the ampullary nerves now placed under abnormal conditions of excitement. The movements, however, continue during sleep, and this fact tends to show that they cannot be due to sensations of sound. It has been stated that disorders of equilibrium continue after the wounds have completely cicatrised, and the head remains in its new position; hence it would seem that the phenomena are not due to peripheral irritation. Dr. Brown-Séquard states that the symptoms do not depend on the section of the canals, "but are the results of an irritation of the auditory nerve, from the traction upon it by the membranous semicircular canals at the time of division." He does not think that auditory sensations play any part in the production of the movements. It has also been shown that, when the operation has been very carefully performed, after a time, the pendulum-like movements either partially or completely cease, and that rotatory movements are developed only when the cerebellum has been injured or has subsequently become affected.

According to Dr. Crum Brown, it is by means of the semicircular canals that we are made aware of the axis, rate, and direction of rotation of the head and body, apart from all other channels of perception. If a man be placed on a revolving disc, with his eyes bandaged, he can, up to a certain point, indicate pretty accurately the amount of movement; but after a time, this cannot be done, and eventually the sense of rotation entirely disappears. When the movement is stopped, the sensation is that of being whirled in the opposite direction; and if the bandage be removed, a distressing sense of vertigo comes on, explicable by the discord between the visual, tactile, and labyrinthine impressions. The hypothesis is that rotation in a plane perpendicular to any of the canals causes the endolymph, on account of its inertia, to press in the reverse direction against the ampullary nerves. This gradually ceases as the movements of the liquid and bony canals become equalised, and so the rotation ceases to be felt. On the stoppage of the rotation, however, the endolymph continues to move on, and an impression of rotation in the reverse direction is occasioned.

"The canals on each side are in three planes at right angles to each other, and we learn the movements of our bodies with regard to the three dimensions of space by means of impressions from the ampullary endings of the auditory nerve; these impressions are set up by the varying pressure of the endolymph in the ampullæ. Thus a sudden turning of the head to the right will cause movement of the endolymph towards, and therefore increased pressure on, the ampullary nerve-endings of the right horizontal canal and diminished pressure on the corresponding nerve-endings of the left side." *

One canal can be affected by, and transmit the sensation of, rotation about one axis in one direction only; and for complete perception of rotation in any direction about any axis, six canals are required in three pairs, each pair being in the same or parallel planes, and their ampullæ turned opposite ways. Each pair would thus be sensitive to any rotation about a line at right angles to its plane or planes, the one canal being influenced by rotation in one direction, the other by rotation in the opposite direction (Crum Brown). These conditions are fulfilled by the fact that the two horizontal canals are on the same plane, and the superior vertical canal on one side is in a plane parallel to that of the posterior vertical canal on the other side, and *vice versâ*.

The Function of the Cochlea.—The cochlea is the peripheral organ for auditory sensations, which commence in excitement of the terminal fibres of the cochlear nerves. According to one theory, certain structures in this part of the ear resolve the complicated wave-forms of musical tones into their components. Helmholtz considered that the rods or pillars of Corti were the apparatus that vibrated and stimulated the terminations of the nerves; but this view was found to be incorrect. In birds and amphibians, which are able to distinguish musical tones, these rods are absent; and the stretched radial fibres of the membrana basilaris, on which Corti's cells are placed, were subsequently regarded as the essential organs in question. According to this theory, which was advanced by Hensen, these fibres behave towards the vibrations of the endolymph as the strings of a piano towards vibration of the air caused by different notes. Different strings in the piano vibrate with different notes, particular strings respond to particular notes; and the fibres of the basilar membrane were thought to respond in an analogous

---

* Kirkes' *Handbook of Physiology*, p. 276.

manner.* "These responsive vibrations, although of infinitesimal magnitude, extend to the particular hair-cells resting on the membrane, and give rise to excitations, which, conducted along nerve-fibres to the brain, produce different auditory sensations." Thus the basilar membrane and the hair-cells of Corti constitute an apparatus by which sound-vibrations are analysed and differentiated at the periphery. The fibres of the basilar membrane increase slightly in length from the base to the apex of the cochlea; the shortest are only about ⅕mm., and the longest about ⅓mm. in length. Dr. Rutherford has pointed out that the fibres are so heavily damped by layers of cells cemented to them on both surfaces of the membrane and along their whole length, that they are ill adapted for resonance. Moreover, in the bird's cochlea there are two layers of fibres, and irregular fibres running between them. Another argument may be adduced against Hensen's theory. If Corti's membrane (*membrana tectoria*) had consisted of a single layer of tense parallel fibres, each cemented to the hairs of a series of Corti's cells, and varying much in length throughout the cochlea, Helmholtz and Hensen would not have been so unreasonable in ascribing stimulation of Corti's cells to a segmented vibration of the superjacent fibres. But the sound-waves first encounter the comparatively lax membrane of Corti, and, after affecting the hair-cells, reach the heavily-damped subjacent basilar membrane, which is in a most unfavourable position for the analysis of sounds.

An alternative theory, proposed by Dr. Rutherford, is supported by several English physiologists; it has been called, by way of distinction, the *telephone* theory. It is supposed that there is no analysis of sound in the cochlea; that all the hair-cells may be affected by every sound, simple or complex, and through them the sound-waves are translated into nerve-vibrations of corresponding frequency, amplitude, and wave-form; that in the sensorium the nerve-vibrations give rise to sensations varying in quality with that of the incoming impulses. It is not to be understood that the hair-cells transform the mechanical vibrations of sound into an entirely different mode of motion analogous to electricity. The essential point is that the analysis of sounds takes place in the brain, and not in the cochlea. A single hair-cell, nerve-fibre, and sensory cell might suffice to give us all the different-sound sensations; but probably the great number of auditory terminals and sensory cells renders us far better able to feel slight differences in the quality of sounds.*

---

* Waller's *Human Physiology*, 3rd edit. p. 472.

Dr. Waller thinks that the basilar membrane may be regarded "as a long, narrow drumhead, repeating the complex vibrations of the membrana tympani, and vibrating in its entire area to all sounds—although more or less in some parts than in others—giving what may be designated as acoustic pressure-patterns between the *membrana tectoria* and the subjacent field of hair-cells. In place of an analysis by consonation of particular radial fibres, it may be imagined that varying combinations of sound give varying pressure-patterns, comparable to the varying retinal images of external objects."

With regard to this theory, Dr. Rutherford thinks that if the hairs of Corti's cells are to be subjected to different pressures in different parts of the cochlea, dependent upon the unequal vibration of a tense membrane, such a membrane ought to be undamped, and placed in contact with the hairs of Corti's cells on the side of the entering sound. But the basilar membrane is heavily damped, and is reached by the sound-waves only after having traversed Corti's cells. It may be stated in conclusion that neither experiments on animals nor pathological observations on man have enabled physiologists to accept any one theory as absolutely conclusive.

The auditory area was localised by Ferrier † in the first temporal or temporo-sphenoidal convolution. In experiments upon monkeys, electrical irritation of this part was followed by quick retraction or pricking of the opposite ear, associated frequently with opening of the eyes, dilatation of the pupils, and turning of the head and eyes to the opposite side. These are just the phenomena which occur when a shrill sound is suddenly made in a monkey's ear. When the centres on both sides were extirpated, the animal was completely deaf; it took no notice of various sounds, which in other monkeys caused signs of alarm and perturbation. Schäfer‡ has questioned the validity of the conclusions drawn from Ferrier's experiment; he found that in six monkeys, after destruction of the superior temporal convolution on both sides, hearing was not perceptibly affected. But subsequent researches, undertaken by Ferrier, confirmed his view, which is further supported by the post-mortem examination of several cases in which complete bilateral deafness was associated with atrophy of the angular gyri and superior temporo-sphenoidal convolutions of both hemispheres. Moreover, "word-deafness" has been found associated with lesions of the superior temporal gyrus in the left hemisphere. In this condition, the patient is not altogether "devoid of auditory sensation, for he can hear the ticking of a watch, and can recognise and hum an air; but articulate sounds, except perhaps his own name, or some simple combination of words, have no meaning and cannot be repeated." Further confirmation of the localisation of the auditory centre in the convolution referred to, is afforded by cases in which subjective auditory sensations of various kinds were connected with irritative lesions implicating this gyrus. Cases of this nature have been reported by Sir W. Gowers* and Hughes-Bennett. It would appear that the fibres of the auditory nerve decussate in the brain, for if the cochlea be destroyed on the side on which the temporal convolution is injured, the animal becomes completely deaf.

---

* "On Tone-Sensation with reference to the Function of the Cochlea," *British Medical Journal*, 1898, vol. ii. p. 353.

† *Croonian Lectures on Cerebral Localisation*, 1890, p. 75.

‡ *Brain*, vol. x. p. 373.

---

* *Diseases of the Nervous System*, vol. ii. p. 21.

CHAPTER XXXIX.

ETIOLOGY, SYMPTOMS, AND DIAGNOSIS OF DISEASES OF THE INTERNAL EAR.

Comparative Frequency of Diseases of the Labyrinth—Three Classes of Causes: General, Local, and Traumatic—Infectious Diseases—Liability of Auditory Nerve to be Attacked—Nervous Deafness—Morbid Conditions of Organs of Circulation, etc.—Effects of certain Drugs upon the Internal Ear—Diseases of the Brain—Extension of Morbid Processes from the Middle Ear—External Influences, Cold, Shocks, etc.—Symptoms of Disorders of the Labyrinth—Deafness—Paracusis—Subjective Sensations—Giddiness and Disorders of Co-Ordination—Nausea and Vomiting—Diagnosis between Diseases of the Labyrinth and those of the Cerebellum—Acoustic Hyperæsthesia—Prognosis—Diagnosis of Diseases of the Labyrinth—Condition of Membrana Tympani and Eustachian Tube—Deafness as a Symptom—Bone-Conduction—Rinne's Test—Drawbacks connected with Rinne's Test—Schwabach's Test—Tests for Duration of Sound-Perception—Testing with High and Low Notes—Galton's Whistle—König's Rods—Summary of Conditions Indicative of Disease of Labyrinth.

Diseases of the Labyrinth are of either primary or secondary origin; those of the former class are relatively infrequent, constituting about 5 per cent. of all cases of affections of the ear. Secondary disease of the labyrinth is not uncommon, for it is apt to supervene upon adhesive and other processes in the middle ear.

The **Causes** of affections of the labyrinth may be divided into three classes. The first will include those of a general character, and depending on infectious diseases and on disorders of nutrition and circulation; the second, those which are local in their origin, the labyrinth participating in morbid conditions of neighbouring parts. The third class includes external influences, such as cold and injuries of various kinds.

I. Among the causes belonging to the first class, various infectious diseases occupy a prominent place. The part that the acute exanthemata, the continued fevers, syphilis, mumps, etc., often take in the causation of middle-ear affections has been fully discussed in a previous chapter; in a smaller proportion of cases, grave disorders of the labyrinth originate in a similar manner, either with or without any implication of the structures of the tympanum.

The auditory nerve is more readily affected by morbid poisons circulating with the blood than any other nerve of special sense. Affections of the optic, gustatory, and olfactory nerves are seldom associated with infectious diseases. It must be confessed that little is known with regard to the changes in the auditory nervous apparatus; but their existence may be inferred from the symptoms. Instances of this character are those cases of absolute deafness without obvious tympanic lesions, associated with diphtheritic paralysis affecting various parts of the body.*

Auditory perception sometimes becomes weakened during the course of non-infectious chronic disorders of an exhausting character; and such a loss of function may eventually become permanent. Closely allied to these cases are those of so-called "nervous deafness," in which there is no recognisable disease, either in the organ of hearing or in the system generally; but the patients are weak and low, and their hearing-powers are more or less diminished. Some authorities—*e.g.*, Dr. Roosa and the late Mr. Hinton—have refused to acknowledge such a causation; but mainly on the grounds that in many cases described as instances of "nervous deafness," some affection of the middle ear can be detected on examination. "Besides, it cannot be said that nervous people are especially liable to deafness from lesions of the labyrinth, any more than they are to atrophy of the optic nerve. On this point, Mr. Hinton says that it is difficult for him to accept debility, nervous or other, as a cause of nervous deafness." †

It is, however, far more probable that functional impairment of the auditory nerve may occur in cases of debility and nervous depression, and without any demonstrable lesion. There are two possible explanations as to the manner in which the organ of hearing is influenced by the state of the general system. 1. The auditory nerve may become impaired in its function by sharing in the general nervous depression, the resulting condition being analogous to nervous asthenopia. 2. The deafness may depend, in part at least, upon atony or paresis of the tensor tympani muscle. Should there be partial deafness, due to middle-ear disease, any condition of debility is likely to increase the loss. A case of this character is reported by Mr. Cresswell Baber.* The patient became suddenly deaf after nursing her father through a long and fatal illness. The nervous deafness was complicated with middle-ear disease, and yielded to treatment, while the latter remained unaltered. But the labyrinthine disorder may come on in the absence of any disease of other parts of the ear.

---

* A marked case of this character is reported by Dr. H. Tooth, *British Medical Journal*, vol. i. 1893, p. 520.

† Roosa, *Diseases of the Ear*, 7th Edition, p. 614. See also Hinton, *The Questions of Aural Surgery*, pp. 153, 245.

It is necessary to remark that the diagnosis of "nervous deafness" must not be too hastily made. The results of many post-mortem examinations, made by the late Mr. Toynbee, go to prove that not a few disorders of hearing, formerly classed as "nervous deafness," are really caused by ankylosis of the stapes.

Various morbid conditions of the heart and lungs are liable to affect the auditory nerve by obstructing the circulation of blood in the cerebral vessels. Degenerative diseases of the kidneys and liver, and some gastric and uterine disorders, are occasionally associated with symptoms referable to the same nerve. In some cases, the association is doubtless accidental; but in others, the connection would seem to be direct, inasmuch as the aural symptoms are wont to vary from time to time, their gravity seeming to depend, in some measure at least, upon the condition of the original lesion. In pregnant women and during the period of suckling, temporary deafness is sometimes noticed; and in women at the menopause, the general and local neurotic disorders tend to aggravate any existing aural affections, and to cause the reappearance of those that have subsided. Noises in the ears are apt to become very troublesome at this period, and are sometimes associated with vertigo and diminution of hearing-power. Adhesive processes in the middle-ear are prone to advance with increased rapidity.

---

* *British Medical Journal*, vol. i. 1893, p. 407.

Effect of Drugs upon the Ear.—Akin to the functional disorders of hearing noticed in the above paragraphs are those symptoms which are liable to be produced by certain drugs, such as quinine, salicylic acid, morphine, and lead, and by the immoderate use of alcohol and tobacco. Large doses of *quinine* almost invariably affect the organ of hearing, and produce subjective noises, as of bells ringing in the ear, while the patient becomes more or less deaf for a time. Ringer states that sometimes, though very rarely, the deafness becomes permanent and complete; as a general rule, however, the noises cease in a short time (in a few hours or days), and the hearing again becomes natural. Dr. Kirchner, of Würzburg, gave large doses of quinine to rabbits, and on killing the animals and examining the ears, found hyperæmia and hæmorrhages in the mucous membrane of the tympanum and in the labyrinth. He attributes these appearances to vaso-motor disturbance, leading to congestion and exudation. Kirchner's experiments have, however, been repeated by Hans Brunner and others; and it would seem that large doses of quinine produce conditions of an entirely opposite character. In the eye, as seen by the ophthalmoscope, the appearances are those of marked anæmia; while the meatus and the tympanic membrane are rendered unusually pale, and the temperature in the former is considerably reduced. Kirchner's experiments were performed mostly on rabbits and cats; and in these animals even small doses of quinine produce violent dyspnœa, with epileptiform convulsions, terminating in death. Moreover, quinine in full doses has a paralysing effect upon the intracardiac nerves. Among other marked symptoms caused by *salicin* and its derivatives, deafness and noises in the ears are commonly noticed. Hydrobromic acid will lessen the effects of these drugs, as well as those of quinine; and ergot is said to have a similar power of preventing or removing the unpleasant singing. *Opium* produces some amount of deafness; "it is said to lessen the conductivity of sensory nerves, though this blunted sensibility must be due in some measure to the effect of opium on the grey matter of the brain, depressing the power of perception" (Ringer). In the organ of hearing, the effects of chronic poisoning by *lead* take the form of noises in the ears. vertigo. and gradually increasing deafness. They are sometimes witnessed among painters, plumbers, and white lead manufacturers. The symptoms may be either acute or chronic. The former are probably due to serous exudation in the labyrinth; and the latter to degeneration of the auditory nerves, as a result of continuous trophic disorder in the sympathetic system. Acute symptoms generally yield to iodide of potassium in full doses, warm baths, and subcutaneous injections of pilocarpine. Symptoms of labyrinthine disorder, resembling those of Ménière's disease, have been occasionally noticed in cases of chronic poisoning by mercury.

II. The second category includes causes of a local origin, the labyrinth participating in, or becoming affected by, morbid conditions of neighbouring parts. In diseases of the brain and its membranes, the connection between the original lesion and the affection of the labyrinth can often be clearly made out. In simple and epidemic cerebro-spinal meningitis (see page 594) and in tumour of the brain, the morbid process extends either by the blood-vessels or along the auditory nerve. It is easy to understand how such conditions as congestion, exudation, and even hæmorrhage in the structures of the labyrinth and atrophy of the nervous structures, may be caused by pressure upon the vessels or upon the auditory nerve. Disorders of hearing, having their seats in the labyrinth, are occasionally associated with lesions of the spinal cord. Aural symptoms of a like character have been known to supervene, as a result of shock or great mental excitement; several cases of this nature are recorded in Mr. Toynbee's work on "Diseases of the Ear." In the absence of any discoverable change in any part of the organ of hearing, such symptoms may probably be referred to some marked circulatory disturbance in the terminal apparatus of the auditory nerve.

The labyrinth is sometimes affected by extension of morbid processes in cases of severe inflammation of the middle ear, especially when occurring in the course of scarlet fever, diphtheria, and measles. The labyrinthine complication may likewise be caused by increased pressure upon the fenestræ. In either case, the prominent symptoms are deafness, noises in the ears, giddiness, and diminished conduction of sound through the bones of the skull. Disorders of hearing referable to the auditory nerve are more common in chronic adhesive catarrh. In this latter affection, which often results in ankylosis of the stapes, signs of labyrinthine disease are not infrequent, and are sometimes noticeable even in the early stages. The disorder of nutrition, leading eventually to loss of function, appears to involve the auditory nerve simultaneously with the middle ear and Eustachian tube. The course of the process is more evident in those severe cases of tympanic suppuration in which the walls of the cavity become carious or necrotic, and the pus finds its way into the cochlea or vestibule, with complete destruction of the terminal nerve-apparatus as the necessary result. In such cases, portions of the osseous walls of the labyrinth, fragments of the semicircular canals, and even the entire cochlea, are sometimes detached.

III. Disorders of the labyrinth are liable to be produced by external influences of various kinds—*e.g.*, exposure to cold; injuries from blows or falls; alterations of atmospheric pressure, and the shocks resulting from very loud or continuous sounds. In cases due to exposure to cold, catarrh of the middle ear generally precedes or accompanies the affection of the labyrinth. Traumatic lesions of the internal ear may result either from direct or from indirect violence. In the former case, the external ear and the tympanum are likewise injured, as in penetrating wounds; the second category includes (1) those cases in which the bones of the head primarily suffer, and the shock is transmitted to the labyrinth, and (2) those in which the injury is effected by shocks or concussions due to changes of pressure, loud noises, etc. Questions as to the influence and frequency of such causes will be fully discussed in subsequent chapters.

In the majority of cases of labyrinthine disorder both ears are affected, either simultaneously or in more or less rapid succession. The impairment of function is, however, likely to be confined to one ear in cases due to the shock caused by a single loud sound. The predisposition to diseases of the internal ear is greatest in children and in persons over sixty years of age. In the latter, the auditory nerve and its terminal expansion are liable to atrophy and fatty degeneration; while children are especially prone to suffer from those infectious diseases which are so often attended by aural complications. An additional reason for the frequency with which children are attacked is supplied by the anastomoses which the vessels of the labyrinth form with those of the middle ear, on the one hand, and of the cranial cavity on the other. These are more frequent in children than in adults; and there is also in the former a freer communication, through the aqueducts, between the fluid of the labyrinth and the cerebro-spinal lymph-spaces.

Symptoms.—Disorders of the labyrinth give rise to (1) Deafness of varying degrees, but generally severe. (2) Subjective sensations (noises in the ears) of various kinds. (3) Giddiness and disorder of co-ordination. (4) Nausea or vomiting. (5) Acoustic hyperæsthesia, evinced by undue sensitiveness to sounds. Two or more of these symptoms frequently coexist; even severe deafness is sometimes associated with peculiar sensitiveness to loud sounds. In one well-marked class, viz., the apoplectic form of Ménière's disease, the deafness and other symptoms come on very suddenly. The patient, if standing or walking, falls to the ground, and the attack resembles one of cerebral apoplexy. In syphilis of the labyrinth, the deafness, which is a prominent symptom, may become complete within a few hours. In other cases, such as those in which an affection of the labyrinth complicates adhesive catarrh of the tympanum, the symptoms of the former are apt to be slowly and insidiously developed.

(1) **Deafness** due to labyrinthine disease varies considerably in degree in different cases. Thus it may be either very slight or total and absolute; and between these extremes every possible variation exists. Total deafness is pathognomonic of disease of the auditory nerve in some part of its course. Labyrinthine deafness is apt to be progressive; but sometimes the impairment remains stationary for a time. In other cases, the gradual progress of the disorder is interrupted by a sudden change for the worse. The hearing-power in any given case is liable to be influenced by the general health of the patient, by excitement, by excesses of all kinds, and by fatigue of the auditory nervous apparatus. As a general rule, the hearing-power in these patients is at its best in a quiet place, where there are no other sounds to distract the attention.

Deafness to certain notes is sometimes experienced by persons suffering from disease of the labyrinth. Inability to perceive high notes is not infrequent in old people; this fact was mentioned by Wollaston in the *Philosophical Transactions* for 1820.

Sudden deafness for low notes has been observed to follow concussions of the labyrinth from explosions of gunpowder, and in other cases of a similar character high notes are lost. In rare instances there is loss of perception of notes in the middle octaves. Symptoms of this nature point to some affection of the auditory nerve; their gradual development would show that the change was probably of a secondary character, such, for instance, as results from pressure on the labyrinth caused by middle-ear disease. Helmholtz's theory that the perception of tones of different pitch depends upon different nerve-fibres, serves to explain the pathology of the cases under discussion. Experiments show that destruction of the apex of the cochlea, which contains the longest fibres of the basilar membrane, causes deafness to the lower notes. Urbantschitsch points out that partial tone-deafness may also be due to central lesions, and that it must often be difficult to determine whether the cause of the symptom is located in the peripheral apparatus or trunk of the nerve, or in the nerve-centres. It must also be remembered that obstacles to sound-conduction are apt to affect certain notes more than others; imperfect perception may therefore be due to purely physical causes.

Another, but somewhat rare, symptom of labyrinthine disease, is the phenomenon termed *paracusis*, or "false hearing." In this condition a note is not heard correctly, but appears to be higher or lower than it really is, and the difference may amount to half a tone, several tones, or even an octave. If only one ear be affected, two sounds are heard, one being true and the other false, and this condition is termed *paracusis duplicata*, or *diplacusis binauralis*.

A case of this latter kind was reported by Sir Everard Home;* the patient, a music-master, when suffering from catarrh, noticed that there was a confusion of sounds in his ears, and also that the pitch of one ear was half a note lower than that of the other. A single note was not perceived as such, but as two distinct sounds following each other in quick succession, the last being the lower and weaker. Several other cases of double hearing have been placed on record; one of the most interesting is that of Von Wittich,† described by himself. A month after a violent cases of suppurative middle-ear inflammation, he observed that the note of a tuning-fork appeared exactly half a tone higher in the diseased ear than in the healthy one. The same difference was perceived in notes of the middle octave, either when whistled or struck upon the piano. Similar results were obtained when the meatus was plugged with wool or filled with water, and after inflation of the tympanum. Two tuning-forks, one half a tone higher than the other, appeared to yield the same note when the higher was held near the sound ear, and the lower near the diseased one.

---

* *Philosophical Transactions*, 1800.

† Quoted by Gruber, *l.c.*, p. 162, from *Königsberg*. Medicin. Jahrb., III. Bd. 1861.

Similar phenomena may be due to the effects of certain medicines. Thus, the late Dr. Moos, of Heidelberg,* has reported a case of "Double Hearing during the Exhibition of Iodide of Potassium." The patient, who had suffered for a long time from nervous asthma, had been taking the iodide in doses of gr. x. daily for a fortnight, when the remedy was discontinued on account of nasal catarrh and loss of appetite. On the following day there was double hearing for certain notes: this subsided in the course of a few days. In another case, reported in the same number of the *Archives of Otology*, the double hearing came on suddenly in a patient who had for a long time been almost completely deaf on the left side. One evening, when humming a tune, he heard the true tone as well as the major third above. He was not, however, sure as to the side on which he heard the higher tone: nor could he define the number of octaves which were affected with the double hearing. While the condition lasted, all varieties of music created great dissonance; subjective noises and vertigo were also complained of. After continuing for seven months, the double hearing passed away, all tones seemed pure, both high and low tones were heard with equal clearness, and music became a source of pleasure, as before. The origin of the symptoms was attributed to inflammation involving the cochlea on the left side and the region to which the vestibular branch is distributed. Their cessation was presumably due to destruction of the conductive capacity of the left auditory nerve, or of its terminal branches within the labyrinth. The results of testing the hearing showed that the left ear was completely deaf for aërial and bone-conduction.

The phenomena of double hearing are explained by Helmholtz's theory, as modified by Hensen, with regard to the resolution of sounds by the cochlea. The stretched radial fibres of the membrana basilaris, on which Corti's organ is placed, and which are shortest in the first turn of the cochlea, "are regarded as the vibrating threads. Thus, a string-like fibre of the membrana basilaris, which is capable of vibrating, corresponds to every possible simple tone."* With a normal condition of the organ of hearing on both sides, a given note throws into vibration corresponding fibres of the basilar membrane, and the proper sound is perceived. When, however, the membrane is more tense on one side than on the other, its pitch becomes raised in proportion to the increased tension, so that a fibre, or a series of fibres, which normally makes 300 vibrations in a second, may execute 350 in the same space of time. When a note corresponding with the latter number is sounded, the healthy ear perceives it correctly; but in the diseased ear, the fibres receiving the impression transmit it to a portion of the sensorium accustomed to receive 300 vibrations, and double hearing is the result.

---

* *Archives of Otology*, vol. xi. p. 27.

An opposite condition is assumed to exist in cases in which the false note is higher than that perceived by the normal ear. The affected fibres of the basilar membrane are supposed to be in a state of relaxation, for example, so as to perform 300 vibrations instead of 325. When a note consisting of the former number is sounded, it throws into vibrations those fibres of the membrane which correspond therewith. On the healthy side, the right note is heard; on the other, those fibres vibrate which normally transmit a sensation corresponding to 325 vibrations, and a note of that pitch is perceived by the sensorial apparatus on that side.†

In connection with paracusis, as in the case of deafness to certain notes, the fact must be borne in mind that morbid changes in the sound-conducting apparatus are apt to facilitate the conduction of certain tones, and to make them appear louder and more distinct. It must also be remembered that under normal circumstances a feeble sound of a given note seems to be of a higher pitch than a loud sound. When any difference in sounds conducted through the air is noticed between the two ears, osseous conduction should, of course, be tested. If the sound then appear to be the same on both sides, the alteration by aërial conduction must be due to some change in the sound-conducting-apparatus.

---

* Landois and Stirling's *Physiology*, 3rd Edition, p. 818.

† For an elaborate explanation of the phenomena of "Double Hearing," see Knapp's paper in *Arch. f. Aug. u. Ohr.*, Bd. I. Abth. 2, S. 96.

It is highly probable that partial tone-deafness and "double hearing" are by no means infrequent. As a general rule, however, the changes are perceptible only by persons whose hearing organs have been well trained. Akin to the phenomena in question are those echo-like sounds which are sometimes superadded to words and musical notes (*diplacusis echotica*), without any alteration in pitch.

(2) **Subjective Sensations** (noises in the ears) will be fully described in the chapter on "Neuroses of the Auditory Nerve." It is here sufficient to mention that in the majority of cases they are caused either by pathological changes in the sound-conducting apparatus or by some affection involving the nerve. In the former case, the noises are most often associated with such lesions as produce rigidity of the membrane of the fenestra rotunda, or undue pressure of the base of the stapes upon the fenestra ovalis. Tinnitus may also be due to peripheral irritation of various sensory nerves, and especially of branches of the fifth pair.

(3) **Giddiness and Disorder of Co-ordination** are frequently due to some disease of the ear. Symptoms of this character, but usually of a slight nature, are sometimes caused by foreign bodies in the external meatus. The pressure upon the membrana tympani increases the tension in the labyrinth, and irritates the vestibular and ampullary nerves. Even syringing the ear, particularly if cold water be used, produces vertigo in some patients. Middle-ear disease, by involving the labyrinth, not infrequently causes marked giddiness and staggering, and sometimes even loss of consciousness. Changes of tension in the tympanum produce more or less corresponding changes in the endolymph, and these latter are regarded as the immediate cause of the vertigo. In a case of middle-ear catarrh, recorded by Dr. McBride,* vertigo, tinnitus, vomiting, and loss of consciousness were all well-marked symptoms, and a very peculiar effect was produced by the first attempt to inflate the tympana. Air passed into the middle ear only on the left side; "but whereas before the operation the patient had great difficulty in standing and

---

* Auditory Vertigo, *Edin. Med. Journ.* Jan. 1881.

walking, even with assistance, after the inflation he declared himself greatly relieved, and was able to walk about alone and unsupported." After a short course of treatment, which consisted mainly in inflating the middle ear, "the only symptom of vertigo left was that looking down suddenly produced slight giddiness." The connection between the nervous phenomena and the condition of the left tympanum was proved by the fact that inflation produced an immediate and marked improvement.

The capability of pressure to produce vertigo is further demonstrated by a case recorded by Dr. Hughlings Jackson.* The patient, a woman aged forty-nine, had suffered from disease of the right ear since childhood, and for three months from giddiness and inability to walk without staggering. Pressure on the tragus was followed by movements of the eyes from side to side, giddiness, and a sensation of falling towards the left side. On examination, the right meatus was found to contain much pus; the membrana tympani could not be seen (owing to swelling of the walls of the meatus), and the watch could not be heard on that side. After some weeks' treatment, the condition became so far improved that, to produce the giddiness and movement of external objects, she had to put the finger into the meatus. The symptoms eventually altogether subsided, the improvement coinciding with the cessation of the discharge from the ear.

The pathogeny of vertigo as a symptom of disease of the labyrinth will be fully discussed in the chapter on Ménière's disease. It is probable that in the large majority ot cases of auditory vertigo, the affection of the labyrinth is secondary to diseases of the tympanum. Primary inflammation of the membranous labyrinth is a very rare disease. Those cases which Voltolini, of Breslau, described as otitis labyrinthica, with deafness and a staggering gait as prominent symptoms, were proved by Gottstein to be in reality mild cases of epidemic cerebro-spinal meningitis. The disorder of the labyrinth cannot be regarded as primary unless it occur in the absence of any sign of middle-ear disease. In such a case, the sudden development of noises in the ears, or the exaggeration of those previously heard, and giddiness, followed by more or less marked deafness,

---

* On "Ocular Movements, with Vertigo, produced by Pressure on a Diseased Ear," *Ophthalmol. Soc. Trans.* vol. iii.

[illegible] diagnosis is sup- [illegible] skull be lost or [illegible] may also be expected [illegible] of vertigo are followed [illegible] has been ascribed [illegible] experienced by the [illegible] through [illegible] a different ex- [illegible] of the semicircular canals [illegible] brain-area, which [illegible] sensation of vertigo. It [illegible] this centre is [illegible] and cardiac in- [illegible] relation is [illegible] of nausea and [illegible] sufficiently [illegible]

[illegible] but such [illegible] and in many [illegible] disease.* It is quite [illegible] may excite an [illegible] the ear alone is not [illegible] a process of irradiation [illegible] the auditory nerve. The [illegible] nausea and vomiting especially [illegible] that the cause of the [illegible]

Nausea and Vomiting [illegible] labyrinthine dis- [illegible] and disturbance of [illegible] as a whole, are by no [illegible] they are of frequent [illegible] disease. In aural cases [illegible] the semicircular canals; [illegible] the vomiting is [illegible] to the vertiginous centre, and subsequent [illegible] of the vomiting centre.

[illegible] especially those affecting th [illegible] give rise to disorder of equilibrium an vomiting, and the symptoms therefore resemble those of disease of the labyrinth. "There may be lesion of the hemispheres without any marked symptoms; but if the middle lobe be injured or pressed upon by a tumour, there is usually a reeling or staggering gait, like that of a drunken man. Ross points out that if the tumour affect the upper part of this lobe, the tendency is to fall backwards, and if the lower part, to fall forwards, or to revolve round a horizontal axis." *

---

* "Remarks on Aural Vertigo," by Dr. S. Mackenzie, British Medical Journa vol. i. 1884, p. 953.

The diagnosis between affections of the cerebellum and those of the labyrinth may be made by considering the additional symptoms in each case. According to Prof. Rosenthal,† in cerebellar disease, the reeling, staggering gait of the patient is but little improved when support is afforded; he walks and stands with his legs far apart, the toes and the metatarsus are alternately raised and depressed, so that sometimes the balls of the toes, sometimes the heel, and sometimes the flattened sole come into contact with the ground. Not infrequently the patient complains of a feeling of numbness in the legs, especially in the soles of the feet; tactile cutaneous sensibility is at the same time much diminished, or even completely lost; the temperature sense and common sensation remain unchanged. Other symptoms occasionally present are: disorder of speech, nystagmus, deviation of the eyeball or inability to raise the eye beyond the horizontal line, contraction of the pupil, and amblyopia with optic neuritis. Violent pain in the back of the head, coming on in paroxysms, and sensitiveness to pressure, are also symptomatic of disease of the cerebellum.

Vertigo, nausea, and vomiting, accompanied by deafness and subjective auditory sensations, indicate some affection of the ampullary nerves, especially when such symptoms are superadded to aural disease, and are unaccompanied by others referable to the cerebellum. It must, however, be remembered that reflex symptoms of the latter kind may have their starting-point in some disease of the ear—*e.g.*, in suppurative inflammation of the tympanum. Urbantschitsch points out that symptoms indicative of cerebellar irritation, appearing from time to time during the course of an aural affection, and decidedly corresponding with its stage and condition, are to be regarded as of reflex origin, and not as proofs of cerebellar mischief.

---

* Landois and Stirling's *Physiology*, p. 725.

† Cited by Urbantschitsch, *l.c.* p. 389.

(5) **Acoustic Hyperæsthesia** is a symptom of hyperæmia and inflammation of the membranous labyrinth. It also occurs in some patients presenting symptoms of general anæmia, and is then probably due to passive congestion of the labyrinth. Certain lesions affecting the auditory nerve are apt to cause increased sensitiveness to loud noises, and even to ordinary sounds. The sensation, under such circumstances, may be accompanied by pain and distress; and this peculiarity is noticed even in deaf people, to some of whom loud sounds are apt to cause great annoyance. Further details on the subject of acoustic hyperæsthesia will be given in the chapter on "Neuroses of the Auditory Nerve."

The **Prognosis** in the majority of cases is very unfavourable; as a general rule, pronounced affections of the labyrinth are not amenable to treatment. Some of the worst cases are those in which the symptoms have appeared during the course of an acute infectious fever, and those of which a gradual development is the marked characteristic. Before venturing upon a prognosis, it is generally desirable to keep the patient under observation for some time. Variations in the severity of the symptoms are not uncommon; the hearing-power is sometimes influenced by the patient's general condition, and other circumstances. In traumatic cases, with comparatively slight symptoms, the prognosis is much more hopeful. In recent syphilitic cases also, recovery may be expected under proper treatment, even when the deafness is considerable, and noises in the ears form a prominent symptom.

Diagnosis of Diseases of the Labyrinth.—In all cases of deafness, the determination of the seat of the lesion is, of course, indispensable for prognosis and treatment. The external and middle portions of the ear are to a great extent accessible to direct examination, and many affections of these parts can be distinguished with absolute accuracy. The case, however, with regard to the labyrinth is altogether different. We have here to deal with a complicated nervous apparatus, closely connected with the brain on the one side and with the tympanic cavity on the other, liable to become implicated in diseases of adjacent structures, and altogether inaccessible to direct examination. Moreover, the pathological changes to which the internal ear is liable have not as yet been fully investigated, and the connection between symptoms and lesions is sometimes very difficult to trace. There are other sources of obscurity in the diagnosis of diseases of the labyrinth. It seldom happens that this part alone is the seat of change; in the majority of cases, the middle ear is likewise affected, and the task of assigning to each part its due share in the production of the symptoms is often beset with difficulties, and is sometimes quite impossible.

The methods of diagnosing aural affections in general have been described in a preceding chapter; a few pages will now be devoted to a special consideration of the means to be adopted for detecting disorders of the labyrinth and for distinguishing them from affections of the middle ear.

The existence of disease in the labyrinth is ascertained (1) by reviewing the symptoms and history of the case; (2) by determining the condition of the external and middle ear; (3) by examining the state of the auditory function.

(1) The general symptoms of diseases of the labyrinth have been discussed in preceding pages; those most frequently met with—viz., deafness, subjective sensations, giddiness, and disorder of co-ordination—even when associated, are by no means pathognomonic of primary labyrinthine disease, for they are sometimes present in catarrh of the middle ear, some of them being due to pressure of the effusion upon the fluid of the labyrinth. When, however, the deafness and the subjective sensations have occurred suddenly; when both ears are involved; when there is a history of syphilis, of injury to the head, or of exposure to loud or to continuous sounds, the labyrinth, in all probability, is the primary seat of the disease. The conviction is strengthened if no disorder of the external or middle ear can be detected on examination made soon after the appearance of the symptoms. After the lapse of some time, the diagnosis is not much aided by such an examination, inasmuch as changes in the middle ear—*e.g.*, a copious exudation—may have passed away, and the disordered function may be due to the condition of the ossicles or fenestræ.

(2) In cases of suspected disease of the labyrinth, the condition of the membrana tympani and of the Eustachian tube must of course be carefully noted. If these structures be

[illegible]

[illegible] can be restored [illegible] of the air-douche.

[illegible] hearing-distance for voice and [illegible] ascertain the acuteness of the perception [illegible] bones of the head. If a loudly ticking watch, placed on the vertex or in contact with the mastoid process, be not heard at all in a patient under sixty years of age, there is reason to suspect disease of the labyrinth; and if a still louder sound, such as that produced by the acoumeter, be scarcely audible under the same circumstances, the probability is decidedly increased.

Still more definite information is derived from the use of tuning-forks. In some cases, the hearing power is diminished for certain tones, while others are distinctly heard; it is therefore necessary to employ a series of tuning-forks, extending over several octaves. A complete set would include c, with 132 vibrations; g, 198; c^1, 264; a^1, 440; d^2, 595; g^2, 792; and c^3, 1,056. For most purposes, however, three are sufficient, viz., c, with 132; c^2, 528; and c^4, 2,112. In deafness due to disease of the nerve, the hearing-power for high notes is apt to be considerably diminished, or even lost, while low notes may be distinctly heard. This symptom, however, even when very marked, is not sufficient to establish the diagnosis, for it is sometimes noticed in connection with altered tension of the membrana tympani and chain of ossicles.

The bone-conduction of sound is tested in the usual way; to determine the relative capacity of the two sides, the fork is placed on some point of the median line of the head, the spots usually selected being the vertex, forehead, and central incisors of the upper jaw. When the perceptive capacity of the nerve on one side is the point to be determined, the forks should be placed on the mastoid process. As explained in a previous chapter (see page 101), in a case of unilateral deafness, if the tuning-fork, placed on the vertex, be best heard on the affected side, it may be inferred that either the external or the middle ear is the seat of the disease. The labyrinth may not be quite normal; but it cannot be seriously involved. On the other hand, in cases of disease of the labyrinth or of the nervous apparatus, the sound of the tuning-fork is always best heard by the normal ear, provided that the labyrinthine affection, on the other side, is not complicated by any disease of the external or middle ear. In using this test, it must be borne in mind that unintelligent patients, suffering from unilateral deafness, due to middle-ear affections, are apt to assert that they hear the sound of the tuning-fork (placed on the head) on the unaffected side. They think that they ought to hear it on that side; and it may be difficult to persuade them that they are mistaken. The surgeon must endeavour to make such patients understand the necessity of careful observation. Even fairly intelligent persons may find it difficult to determine the side on which the sound is better heard. In such cases, it is well to vary the position of the tuning-fork, *e.g.*, to apply it in succession to the vertex, the glabella, between the middle incisor teeth, and to the median line of the chin. Tuning-forks of different pitch should also be tried. The diagnosis will be aided by noticing whether the use of the air-douche makes any difference. If the sound be less distinctly heard in the affected ear after the tympanum has been inflated, the diagnosis of disease in the sound-conducting apparatus is proportionately strengthened. If during the course of an affection of the middle ear, the sound, in Weber's experiment, become less audible on the affected side, extension of disease to the labyrinth may be inferred.

As a general rule, Weber's test is of less diagnostic significance in bilateral affections than in those in which only one side is affected.

Comparison of the aërial with the bone-conduction of the sound of the tuning-fork yields valuable evidence as to the condition of the labyrinth, and there are several ways in which this comparison may be effected.

Rinne's experiment compares aërial with bone-conduction in a manner which renders it very convenient for diagnostic purposes. A vibrating tuning-fork is applied to the vertex, the mastoid process, or against the incisor teeth. When the sound ceases to be heard, the instrument is removed and held in front of the ear, when the sound again becomes audible. This result is termed *positive*, and is always obtained with a healthy ear. When the sound, conducted through the bones, is heard for as ong a time as, or longer than, through the air, the result is described as *negative*. Rinne's experiment does not directly show to what extent the hearing-power by aërial or bone-conduction is actually diminished; but it measures the difference which is proved by experience to be subject to the greatest variations in disease of the internal ear. If, in a case of marked deafness—*e.g.*, when a whisper is heard only close to the ear—Rinne's experiment yield a positive result, the existence of disease in the nervous apparatus may be fairly assumed, inasmuch as the relations between aërial and bone-conduction have undergone no alteration. On the other hand, in unilateral disease, with marked deafness, a negative result of Rinne's test does not necessarily indicate an affection of the sound-conducting apparatus; for in such a case, bone-conduction from the mastoid process of the affected side to the healthy ear cannot be prevented. Conduction through the bone might then predominate over air-conduction; and thus in a purely nervous affection, Rinne's test might yield a negative result. In all bilateral affections, with no great difference in the hearing-power on the two sides, if the result be negative, that is, if the patient hear the sound conducted through the cranial bones as long as, or even longer than, that conveyed through the meatus, disease of some portion of the conducting apparatus may be diagnosed. There may at the same time be some amount of disease in the labyrinth; and the probability is much increased if perception for high notes, as tested by a tuning-fork held near the ear, be much diminished or altogether lost. It must always be borne in mind that Rinne's experiment, like others based on the patient's own personal observation, furnishes satisfactory information only in the more intelligent classes.

Dr. Schwabach, of Berlin,* has shown that in applying Rinne's test, the result on the same ear, in some cases, may be either positive or negative, according to the tuning-fork employed. He used two forks—one, c with 132 vibrations, and the c^1 of the next higher octave. In 4·8 of all cases, with demonstrable changes in the sound-conducting apparatus, this doubtful result was obtained. Besides this drawback connected with Rinne's test, the conclusions to be deduced from a positive result are not in accordance with Rinne's assertion, for in many cases of indisputable affections of the sound-conducting apparatus, one or other fork could be heard at the meatus after perception through the bones had ceased, and only in a few such instances could it be assumed that the auditory nerve was implicated. Lucae's statement likewise that Rinne's assertions are correct only when marked deafness exists—*e.g.*, when whispered speech can be heard at no greater distance than three feet—does not hold good of all cases. Dr. Schwabach admits that in cases of deafness, with no objectively demonstrable changes in the sound-conducting apparatus, a positive result with Rinne's experiment justifies the assumption of disease in the nervous apparatus.

It is necessary to mention certain other advantages and drawbacks connected with Rinne's test. As a general rule, the test is applicable in bilateral affections, which, however, the number of vibrations; and is probably due to the fact that the slower vibrations of these forks possess a greater potential agency, and are therefore more capable of exciting vibrations in the bones and labyrinth.

---

* *Archives of Otology*, vol. xv. p. 195.

There is another method (Schwabach's experiment) of distinguishing between affections of the sound-conducting apparatus and those of the labyrinth. If a tuning-fork of low pitch (132 v. per second) be forcibly struck, and immediately applied to the vertex of a partially deaf person, and the time measured until the sound ceases to be heard, in diseases of the sound-conducting apparatus, the duration of perception is longer than in health. This test may be applied by placing the fork on the head of a person with normal hearing, and telling him to say "Now" when the sound ceases to be heard. The fork is then immediately applied to the patient's head, and the difference carefully noted. A pathological lengthening in bone-conduction may be inferred when the sound is heard by the patient for at least five seconds longer than by a healthy ear. The tuning-fork, fitted with tube and earpiece (see page 102), may be used in the application of this test.

As might be expected, there are certain sources of error connected with this test. It may be difficult for the patient to determine the exact moment at which the sound ceases to be audible. The duration of perception depends, to some extent, upon the degree of pressure with which the tuning-fork is applied to the head; and a few seconds are lost in transferring the instrument. It is, moreover, doubtful whether the duration of perception is equal in all individuals whose hearing organs appear to be normal. The interval certainly becomes shorter in advanced age. To obviate as far as possible the first difficulty, the experiment should be repeated several times, care being taken to apply the instrument with a uniform degree of pressure. To ensure that the tuning-fork should always be struck with the same amount of force, some authorities recommend an instrument fitted with a rubber hammer, which, being withdrawn for a definite distance and then let go, flies back and strikes the prong. In this way a sound of unvarying and moderate intensity is easily obtained. Hartmann's experiments, however, show that sounds of equal duration can be produced by striking the fork in the usual way.

The duration of sound-perception may be tested in another way. Two-tuning-forks are used: one corresponding with a^1 (440 vibrations), and the other two octaves lower (110). The former, if permitted to vibrate freely in the air, can be heard for 80 seconds by a person of normal hearing, for 11 seconds if placed on the vertex, and then for 30 seconds more by aërial conduction if held in front of the meatus. Under similar conditions, the second fork, if struck moderately hard, can be heard for 90, 24, and 42 seconds respectively. It must again be remembered that the more firmly the tuning-fork is pressed against the head, the sooner the instrument comes to rest and the sound ceases. When using a large tuning-fork, the pressure can be easily regulated by holding the handle perpendicular to the surface of the vertex, and allowing the fork to be kept in place by its own weight. A diminution of the difference in the duration of perception between bone-conduction and air-conduction would indicate a lessened capacity of the sound-conducting structures. When the difference proves to be normal, or but very slightly reduced, and there are no obvious signs of disease in the tympanum, the deafness must be due to a lesion of the sound-perceiving apparatus.

A comparison of the hearing-power, by air-conduction for high and low notes respectively, is another means of aiding the diagnosis; and for this purpose it is well to use two tuning-forks, one making about 110, and the other about 2,800 vibrations in a second. When many deaf persons are thus tested, it will generally be found that, in addition to reduced hearing-capacity for speech, the sounds emitted by one or both tuning-forks will be heard less distinctly than by a normal ear. In one class of cases, the perception of high and low notes is diminished in an equal degree. In another, the deafness is especially marked for one end of the scale. If the high note be much less distinctly heard than the low one, disease of the sound-perceiving apparatus may be inferred to exist. The sound-conducting structures may at the same time be either normal, or more or less affected. If the reduction in hearing-power prove to be the same for the two classes of notes, or more marked for low tones, no special inference can be drawn as to the seat of the lesion.

In using this test, the low-pitched fork is made to vibrate and held close to the ear of the patient, who is instructed to say

"Now" when he ceases to hear it. The surgeon then brings it equally close to his own ear (assuming it to be normal) and notes the loudness of the sound and the time during which it is audible. A tuning-fork fitted with a T-shaped tube may also be employed in this method of testing. One branch is placed in the ear of the patient, and the other in that of the surgeon (see page 99). The high-pitched fork is then used in a similar manner, but the patient should close his other ear. If the second fork, which has ceased to be heard by the patient, be perceived by the surgeon at a much greater distance than the low-pitched fork similarly used, it may be inferred that the hearing-power for high notes is much more reduced than it is for low ones. On the other hand, if the distance be about the same with both forks, it may be assumed that the patient's hearing capacity has suffered in an equal degree for both classes of notes. It must be remembered that a tuning-fork of low pitch, when forcibly struck, can be heard by a normal ear at a distance of not more than 3 or 4 inches; whereas an instrument yielding 3,000 vibrations, when much less forcibly struck, can be heard at a distance of 20 yards or more. If a patient hear the low tones when the fork is gently struck, but the high ones only when the instrument is made to vibrate with considerable force, it is evident that his hearing-power for high notes is decidedly reduced. When such a reduction can be clearly demonstrated by the methods already described, disease of the sound-perceiving apparatus may be almost certainly inferred.

Galton's whistle and König's rods are convenient instruments for testing the perception of high notes. The former (Fig. 33, page 96) is made to produce the higher notes of the musical scale by means of a rubber ball fitted to one extremity. The note becomes higher as the length of the tube is diminished by the advance of a plug.

König's rods are employed for the same purpose as Galton's whistle. The rods are suspended by loops of silk or fine wire, and in order to obtain a definite intensity of sound, a small steel pendulum, swinging through an arc of 90°, hangs from the same beam as the steel rod. A graduated scale, over which the pendulum swings, is also attached to the beam, and by its means the force with which the rod is struck can always be estimated and repeated as often as necessary.

These additions were suggested by Dr. Blake, of Boston, U.S., who obtained the following results with this instrument. At 12 or 13 years of age, a note of 40,960 vibrations per second was heard at a distance of 34 feet; between 18 and 20, the same tone was heard at from 13 to 16 feet. At from 28 to 30 years, only notes of 32,768 vibrations were audible, and above the age of 50 the limit of perception had still further diminished. For testing the condition of the labyrinth a series of rods are required, yielding 20,000 vibrations and upwards per second.

In most diseases of the external and middle ear, high notes are perceived more readily than low ones. By way of explaining the opposite condition which generally obtains in labyrinthine disease, Brunner supposes that the perception of high notes makes greater demands upon the sensibility of one portion of the nervous apparatus; and consequently that the function of this portion is much more easily and rapidly interrupted by increased waste and pathological processes than happens elsewhere. It is a matter of common experience that in advanced age, perception of the highest notes is considerably diminished and that bone-conduction is also decreased. These alterations are due to senile torpor of the nervous apparatus of the labyrinth. Mr. Galton refers to a proverb in Dorsetshire, that no agricultural labourer who is more than forty years old can hear a bat squeak. .

Diminished perception of high notes is not, however, always met with in cases of labyrinthine disorder. On the contrary, in exceptional instances, low notes are less distinctly heard than high ones; and in very rare cases the perception for both classes of notes is uniformly diminished.

The conditions indicative of disease of the labyrinth, as described in the foregoing pages, may be thus summarised:—

1. In a case of unilateral deafness, the tuning-fork, applied to the vertex, heard best on the healthy side.

2. Hearing-power for low notes, by air-conduction, less reduced than for high notes.

3. The perception of high notes very decidedly reduced; absolute deafness for the higher notes of the scale. The age of the patient must be taken into account.

4. No change in the normal relation between the duration

of bone-conduction as compared with air-conduction; the absolute duration of both being more or less diminished.

5. False hearing—*i.e.*, a note appears to be either higher or lower than it really is. (See page 675.)

6. Partial tone-deafness; certain notes or group of notes are more or less indistinctly heard, the hearing-power remaining normal for higher and lower notes. (See page 674.)

The conditions described under the last two headings are comparatively rare; and such defects could be appreciated only by a well-trained and sensitive ear. It is evident that the nature of the disease must be determined, not by the presence of any one symptom or the use of any single test, but only after a careful examination by all the methods at our disposal, and due attention to the history and special features of the case.

CHAPTER XL.

DISORDERS OF CIRCULATION IN THE LABYRINTH.

ANÆMIA—HYPERÆMIA—INFLAMMATION OF THE LABYRINTH.

Anæmia of the Labyrinth, Causes and Symptoms—Hyperæmia of the Labyrinth, Causes and Symptoms—Diagnosis—Treatment of Disorders of Circulation—Inflammation of the Labyrinth—Pathology—Question as to Primary Origin—Causes—Gruber's Classification—Exudative and Plastic Forms—Cases due to Diphtheria—Appearances in Cases of Cerebro-Spinal Fever—Symptoms—Prognosis—Treatment.

DISORDERS of circulation in the labyrinth often accompany the various forms of middle-ear inflammation, and are discoverable in fatal cases on examination after death. More or less extensive hyperæmia and hæmorrhage are the appearances generally noticed; but their connection with the symptoms has not been clearly determined. There is, however, reason to believe that these changes in the labyrinth set up irritation of the sound-perceiving apparatus, and cause tinnitus, impairment of hearing, giddiness, nausea, vomiting, etc. As a matter of fact, however, the cranial contents are often simultaneously involved in the circulatory disorder; and the symptoms thus produced may mask or modify those due to the condition of the internal ear.

A general condition of **Anæmia** does not necessarily produce any special symptoms referable to the labyrinth, unless hæmorrhage occur into the part itself. In that case sudden deafness is likely to be developed. More or less impairment of hearing power is not infrequent in cases of general debility, exhausting diseases, hæmorrhages, repeated pregnancies, and prolonged lactation; and these conditions tend to aggravate any existing disorder of the middle ear, and increase the liability of the labyrinth to become affected.

Murmurs produced in the cervical vessels are often distinctly perceived by the patient, and seem to originate within the ears, especially when the resonance is abnormally increased, as occurs in middle-ear inflammation, and as a result of accumulation of cerumen. Symptoms referable to the labyrinth, due to anæmia, are less troublesome when the patient assumes the horizontal position, and are generally relieved by stimulants.

Disorder of hearing, as a result of anæmia of the labyrinth and brain, often precedes faintness and syncope; all sounds appear less intense, and tinnitus of various kinds is associated with giddiness and dimness of vision.

A condition of anæmia, limited to the labyrinth, may be due to narrowing or closure of the internal auditory or basilar artery. Sudden deafness has been produced by embolism of the latter vessel. In so-called "Caisson-disease" (see page 255), while the workmen are exposed to the increased pressure, an excessive quantity of air is absorbed by the blood. On leaving the air-chambers, especially if the change be rapidly made, small air-bubbles are set free within the blood-vessels, and are liable to interfere more or less with the passage of the blood. This process may occur in the vessels of the labyrinth, and produce not only anæmia and functional disorder, but actual necrosis of tissue.

Hyperæmia of the structures of the labyrinth is a usual accompaniment of inflammation of the middle ear and in neighbouring tissues, but it also occurs in the absence of any inflammatory processes. Thus tumours, *e.g.*, enlarged glands in the neck, by compressing the veins, may produce marked congestion in the aural structures. A similar result is sometimes due to defective innervation of the inferior cervical ganglion of the sympathetic, to irritation of the fifth pair of nerves, and to affections of the spinal cord. In Bernard's well-known experiment, hyperæmia and increased temperature in the ear are immediately produced by section of the cervical sympathetic. Congestion of the head from any cause is liable to be attended by hyperæmia of the labyrinth; and in most febrile affections, but especially in scarlatina and typhus, there is often more or less congestion of the internal ear. Alcohol [illegible] cases, [illegible] of [illegible] and [illegible] condition. Prominence of the [illegible] or of the internal [illegible] of blood from the internal [illegible]. A similar condition is often [illegible] and in performers on [illegible].

The **Symptoms** [illegible] of the labyrinth are much the [illegible] of more or less deafness, [illegible], often of a pulsating character, [illegible] in the ear and head, giddiness, [illegible]. The symptoms are aggravated [illegible] position. Hyperaesthesia of [illegible] congestion of the labyrinth.

The **Diagnosis** is [illegible] observation of the general condition [illegible] the ear. Hyperaemia of the [illegible] when bone-conduction is [illegible] and when the [illegible] portion of the [illegible] are somewhat hyperaemic, but no [illegible] in the middle ear. In cases in which [illegible] the seat of disease, congestion of the [illegible] increase of deafness and of subjective sensations and by impairment of bone-conduction. These [illegible] aggravated by the [illegible] that the two conditions, anaemia and congestion, are for the most part symptomatic either of some general affection or of some disease of the ear.

The **Prognosis** will depend upon the nature of the associated [illegible]. As a general rule more or less relief can be afforded in all cases of disordered circulation in the labyrinth.

The **Treatment** must be adapted to the co-existing conditions. When the anaemia is part of a general disorder, the various preparations of iron, stimulants, rest, good food, and fresh air are likely to prove serviceable. When, however, there are evidences of congestion of the head, and the vessels of the tympanum are enlarged and prominent, it will be desirable to apply a few leeches over one or both mastoid processes. If the cerebral congestion be very marked, it will be better to take a few ounces of blood by cupping at the back of the neck. At the same time the bowels should be freely relieved by calomel or saline purgatives. In chronic cases, warm foot-baths, with a little mustard, every night, will be of service; and the cerebral symptoms will be further relieved by blisters behind the ears and to the back of the neck. The application of tincture of iodine to the mastoid process is sometimes useful. Massage to the neck is also recommended. The diet and mode of living in other respects must, of course, be carefully regulated. The patient should avoid everything likely to cause determination of blood to the head—*e.g.*, excessive mental work; and if compelled to continue in any such occupation, should, as far as possible, refrain from stooping over it. Bathing the head in cold water is generally inadvisable; it is liable to aggravate the subjective symptoms.

As a matter of course, any existing affection of the ear will require careful attention. In many cases the subjective sensations are relieved, though only for a time, by rarefying the air in the external meatus. The application to the ear of rectified spirit of wine with a little ether has sometimes a good effect; and in cases in which the subjective symptoms are very troublesome, the bromides may be prescribed with advantage.

INFLAMMATION OF THE LABYRINTH—OTITIS INTERNA.

Inflammatory processes are apt to extend to the labyrinth from neighbouring parts; and the complication is most often observed in cases of caries and necrosis of the temporal bone. It is comparatively rare for inflammation to extend from the tympanum or mastoid cells to the internal ear, and cases of this kind are probably due to the influence of micro-organisms. Drs. McBride and Bruce* have recorded a remarkable instance of this character; the morbid process had extended not only to the labyrinth, but to the cerebellum. The patient had suffered from chronic middle-ear suppuration on the right side, with destruction of the membrana tympani and ossicles. Three days before death the tuning-fork was heard best by the diseased ear; hence the nerve and labyrinth were then normal. Sections of the semicircular canals showed copious infiltration with rod-shaped bacteria, masses of which were found between the osseous lamellæ, in the coats of the arteries, and in the diploetic spaces. The veins for the most part contained plugs, made up of enormous numbers of bacteria. Similar organisms were found in the sheath of the facial nerve and in the connective tissue between the fibrillæ. An abscess as large as a walnut, and containing bacteria, was found in the cerebellum on the same side.

---

* "The Pathology of a Case of Fatal Ear-disease," *Journal of Anat. and Physiol.*, vol. xiv.

In very rare cases the inflammation in the labyrinth is secondary to some morbid process within the cranium. In cases of cerebro-spinal meningitis, purulent matter has been known to find its way along the auditory nerve to the internal ear. On the other hand, in cases of injury of the osseous capsule, sero-purulent or hæmorrhagic exudation into the labyrinth may lead to purulent meningitis.

The occurrence of primary inflammation of the labyrinth must now be regarded as proved; though some of the cases recorded under that heading are really instances of secondary mischief. Primary inflammation of the internal ear is especially apt to occur in children, but adults are not exempt from it. A case is recorded by Schwartze* of acute purulent inflammation of the labyrinth, leading to suppurative meningitis, occurring in a woman, thirty-two years of age, and who had been syphilitic for eight months. There had been constant pain in the head, giddiness, and uncertain gait, for some weeks before death; and these symptoms were followed by fever, vomiting, delirium, and coma. On post-mortem examination, pus was found at the base of the brain, and along the course of the vessels in the fissure of Sylvius. The auditory nerve, temporal bone, and tympanum were normal. The cochlea, vestibule, and semicircular canals were filled with a sero-purulent fluid; the blood-vessels of the ampullæ were congested and tortuous, and the saccules of the vestibule were reddened and infiltrated with pus. It would, moreover, appear that labyrinthine inflammation may take the form of periostitis. Thus, in the case of a boy, aged fourteen, who had suffered from otorrhœa and convulsions for two and a-half years, Politzer† found the cochlear spaces to be completely choked up by new-formed osseous material. The vestibule was so narrowed by the hyperplastic process as to form only a small cleft, and the semicircular canals had altogether disappeared. In this case, purulent inflammation had been the first stage, and this had excited connective tissue proliferation from the lining membrane, and ossifying periostitis. Cases of partial and total ossification of the labyrinth as a result of inflammation have also been described by Kundrat, Burckhardt-Merian, and others.

---

* *Arch. f. Ohrenheilkunde*, Bd. xiii.

† *Lehrbuch der Ohrenheilkunde*, S. 496.

Causes.—Nothing definite can be stated with regard to the causes of primary inflammation of the labyrinth. It has been attributed, in different cases, to exposure to cold, to metastasis, and to injuries. The pathological appearances show that various forms of inflammation are liable to occur in the internal ear, and Gruber thinks that at least two kinds may be distinguished, which he terms "exudative" and "plastic." In the former, the exudation may be serous, sero-hæmorrhagic, or purulent; the latter is characterised by hyperplasia of tissue. He thinks that serous exudation occurs in those cases where, without obvious cause except exposure to cold, an ear previously normal becomes deaf in various degrees, and is the seat of more or less marked subjective sensations. Nothing morbid can be detected in the remaining parts of the ear; there are no reasons for suspecting the existence of any central lesion, and all the symptoms disappear in the course of time. It is possible that the exudation may have taken place only in the canal of the osseous spiral lamina. The bundles of nerve-fibres are compressed, and their functions rapidly abolished; but with the absorption of the exudation all the symptoms pass away. In such cases it is more probable that the labyrinth is affected than that the trunk of the nerve is compressed, for in the latter case the lesion would certainly be associated with symptoms referable to other nerves.

If copious exudation be rapidly poured out, as would occur with rupture of vessels, the resulting disorder would be very severe, and probably irreparable. In this category may be placed, according to Gruber, certain cases of loss of hearing occurring in syphilitic subjects. With, or even without, previous catarrh of the middle ear, and perhaps after exposure to cold, an acute affection of the labyrinth comes on, the permanent result of which is total loss of hearing.

Purulent inflammation may occur in the labyrinth as the result of injury and of the invasion of bacteria of various forms. Lesions of the internal ear, of the latter type, may occur in the course of small-pox, scarlet fever, diphtheria, typhus, measles, influenza, and tuberculosis. In all these disorders, the morbid process probably extends from the throat to the middle ear, and thence to the labyrinth; and it is in this last portion that the most decided effects may be produced.

Moos* has recorded an account of three cases of fatal diphtheria, in which the labyrinth was involved, while the tympanum was affected only by catarrhal inflammation. The membranous semicircular canals, in many spots, were partially or entirely blocked up with masses of cells and coagulated lymph. The development of connective tissue, bone, and vessels had already taken place in some of these deposits. In the osseous walls of the labyrinth there were evidences of inflammation, of hyperplasia, and of disintegration. The medullary spaces of the petrous portion and the aquæductus vestibuli were filled with chains of micrococci, which were also found in the endo- and peri-lymphatic spaces of the semicircular canals, but not in the cochlea or vestibule. These micro-organisms were thought to be accidental in diphtheria, but to be capable of producing severe disease of the labyrinth. They may reach the internal ear through the vessels, but they may also find their way thither from the subdural spaces, which are connected with the deep cervical glands, the subdural spaces of the nerve-roots, especially of the auditory nerve, and the lymphatics of the nasal mucous membrane.

The labyrinth is not infrequently affected in severe typhoid. In six cases, examined by Moos, there were evidences of inflammation and hyperplasia in the utricle, sacculus, ampullæ, and membranous *lamina spiralis*, and the semicircular canals were implicated to a less extent. The infiltration was composed of lymphoid and smaller cells.

The appearances found in disease of the labyrinth connected with cerebro-spinal fever more or less resemble those already described. They consist in destruction of the soft parts and new formation of connective tissue and bone. Many pus-cells pass between the nerve-fibrils; a large number of epithelial cells are detached and become indurated; patches of extravasated blood are frequently noticed, and there is more or less degeneration of nerve fibres. Pus cells and extravasated blood are sometimes found in the facial canal and in the aquæductus cochleæ; the structures of the ductus cochlearis may be entirely destroyed, and the cochlea itself filled up with pus, masses of epithelium and detritus, and particles of necrosed bone. In extreme cases, the semicircular canals, the ampullæ, and the vestibule may all be destroyed, and the process not infrequently extends to the middle ear. It has been shown that the lymph-passages of the nose may act as channels for the micro-organisms, which may pass thence into the sub-arachnoideal spaces of the brain, and then into the perilymph. The existence of these means of communication serves to account for the early development of the processes in the ear and their bilateral character.

---

* *Archives of Otology*, vol. xvii. p. 1.

Symptoms.—The evidences of primary inflammation of the labyrinth are by no means clearly defined. In Voltolini's cases, the disease was ushered in by a short stage of cerebral congestion and vomiting. This was followed by elevation of temperature, delirium, and convulsions, which subsided in the course of several days, when absolute deafness and a staggering gait were clearly noticeable. Anatomical investigations were wanting, and in all probability the symptoms were due to meningitis of a rapid type.

Secondary inflammation of the labyrinth is doubtless much more common, though the symptoms are by no means distinct. The diagnosis is mainly effected by testing the hearing-power. If bone-conduction be altogether lost on the affected side, and Rinne's test yield positive results as far as can be made out; if in Weber's experiment the tuning-fork be heard exclusively or much more distinctly on the better side; if high notes be either badly heard or not perceived at all, the evidence in favour of labyrinthine complications is exceedingly strong. The tests must be applied very carefully and on several occasions, and it must be remembered that impairment of hearing for high notes is not a constant symptom, even when the labyrinth is decidedly involved.

The subjective symptoms are not pathognomonic; the patients usually complain of very severe tinnitus, impairment of hearing or complete deafness coming on suddenly, pain in the head, pressure or fulness in the ear, vomiting, giddiness, and loss of balancing power. The extension of suppurative processes from the middle ear to the labyrinth is usually marked by rapidly increasing intensity of all these symptoms.

In cerebro-spinal meningitis, the aural symptoms may appear at the commencement, or not until the termination of the disease; the patient, on recovering consciousness, is found to be deaf, probably on both sides, and to stagger when attempting to walk. Labyrinthine disease, occurring in the course of scarlatina and diphtheria, is generally preceded by suppurative inflammation of the middle ear. The symptoms of labyrinthine complications connected with influenza, mumps, and other kindred diseases have been described in a previous chapter (see page 614, *et seq.*).

Prognosis.—This is for the most part unfavourable, but there is some hope for those cases which occur without fever and are unilateral. Improvement can sometimes be effected in recent cases of syphilitic internal otitis, to be subsequently described. In most patients, however, the impairment of function either remains without change, or gradually proceeds until the stage of total deafness is reached. The subjective sensations are often very obstinate and troublesome; but the evidences of disorder of equilibrium may pass off after a time, perhaps not until the patient has become quite deaf. If children become affected before they have learned to speak, or shortly afterwards, deaf-mutism is the ordinary result, unless great care be taken. When suppuration exists in the labyrinth, the process may extend along the auditory nerve to the cerebral membranes; and when caries or necrosis is superadded, pachymeningitis in the posterior cranial fossa, accompanied by cerebellar abscess, is likely to ensue.

Treatment.—In all cases in which there is reason to suspect that the labyrinth is the seat of inflammation, the treatment must be regulated according to the general condition of the patient and the co-existing circumstances. Any existing disease in the middle ear or nares must be carefully attended to. When there is high fever and the patient is fairly robust, a few leeches may be applied behind the mastoid process on each side; and the bowels should be freely opened by a dose of calomel followed by saline purgatives. Antipyrin, in doses of gr. v.—xv. hourly, for four or six hours, may be used to reduce the temperature. Cold may also be applied to the head by means of ice-bags. If copious exudation have already taken place, as shown by total deafness, there is not much chance of recovery under any treatment; but it is worth while to try the effects of iodide of potassium internally, and of mercurial ointment applied behind the ear. In later stages, blisters to the mastoid process may possibly do a little good. When there is a history of syphilis, a prolonged course of mercury is likely to prove beneficial; and in addition, Politzer recommends the daily subcutaneous injection of two to six drops of a 2 per cent. solution of pilocarpin, and that the dose should be gradually increased. If the remedy cause nausea, giddiness, prostration, and other unpleasant symptoms, it should be replaced by two drops of a solution of atropin (gr. one-third per cent.). In recent syphilitic affections of the labyrinth, and also in some non-syphilitic cases, a remarkably good result is sometimes produced by these remedies. They are, however, useless in hereditary syphilis, in deafness due to epidemic cerebro-spinal meningitis, and in cases complicated by middle-ear catarrh. When the complaint occurs in young children and deafness ensues, the greatest care is necessary to prevent them from losing the faculty of speech. They should be trained to talk as much as possible, and forbidden to make use of signs to express their wants. This subject will be again referred to in the chapter on Deaf-mutism.

CHAPTER XLI.

CONCUSSION OF THE LABYRINTH—INJURIES TO THE LABYRINTH.

Causes of Concussion—Symptoms—Diagnosis—Prognosis—Treatment—Injuries to the Labyrinth—Modes of Production—Variations in Results and Appearances—Symptoms—Diagnosis, Prognosis, and Treatment.

THE labyrinth is liable to be affected, in common with other nervous structures, in cases of concussion of the brain from any cause; but it sometimes happens that the effects of an injury are exhibited principally or almost exclusively by the structures of the internal ear. Thus gunpowder-explosions may do little or no injury to the body in general, while their results are evidenced by the symptoms of auditory disturbance. When due to this cause the concussion may act upon both ears; but, as a general rule, the effects are confined to the ear which is turned towards the source of the explosion. Similar results may be produced by blows or kicks on the head, and even in these cases the symptoms of labyrinthine disorder are not necessarily accompanied by any external injury. Nothing can be definitely stated as to the changes which take place in the implicated nerves or nerve-centres: even in fatal cases there may be an absence of marked structural changes in the various parts of the internal ear.

The **Subjective Symptoms** vary both in kind and degree. When the patient is knocked down by the blow or the force of the explosion, he may be rendered unconscious, and remain in that condition for an indefinite period. In slighter cases, after the shock has passed off, there may be pain in the ear and giddiness, lasting for some hours, or even for some days. Subjective auditory sensations, such as noises in the ears of various kinds, are sometimes complained of, and more or less impairment of hearing is an almost constant symptom. Hearing-power for high notes is apt to be especially affected. In other cases there is abnormal acuteness of hearing for certain notes, or the latter may appear to be higher or lower than usual. Sometimes other notes are heard, mingled with the normal sound. Diminished cutaneous sensibility of the auricle and meatus, even amounting to complete anæsthesia, is sometimes noticed. These symptoms may remain for long periods, disappearing from time to time, and then recurring, or they may soon altogether cease.

Objective Symptoms may be altogether absent: when present, they will consist of marks of injury to the head, and especially to the parts about the ear.

The **Diagnosis** will often present considerable difficulties; in many cases, the patient's own statements will be all that the surgeon has to depend upon, and wilful misrepresentation is not uncommon. Impairment of hearing may be magnified into complete deafness. It is necessary to apply all possible tests for discovering the state of the auditory organs, and also to ascertain their condition previous to the accident. However, after every precaution is taken, the diagnosis in some cases will be one of probability only.

The ear must be tested with the watch and with tuning-forks of various pitch. As a general rule, impairment of bone-conduction is an unmistakable symptom of labyrinthine disorder; but it must be remembered that accidental affections of the bones may impair their conducting-power, and a mistake may thus arise. A plug of wax in the meatus may prevent a watch from being heard even when in contact with the auricle; but when the wax is removed the sound is distinctly perceived. When bone-conduction is unimpaired there is every probability that the labyrinthine structures are in a normal condition. Weber's experiment yields good results as a test in these cases. When the effects are positive—*i.e.*, when the tuning-fork is best heard on the side on which the meatus is closed—there can be no serious affection of the labyrinth. When, however, the results are negative—that is to say, when the change is either not observed, or is of an opposite character—there is strong evidence of the existence of some lesion of the internal ear. Rinne's experiment is of little use as a test in the class of cases now under consideration. In complete deafness it cannot, of course, be employed; but in less severe cases it may be used to test the accuracy of the patient's statements.

Gruber lays great stress on the value, in all doubtful cases, of his method of testing the ear. It consists in holding a vibrating tuning-fork in front of the ear, until the sound is no longer heard. A finger is then inserted into the meatus, and the handle of the tuning-fork is placed in contact with it, when the sound is again perceived by a normal ear. The change is due to the fact that the closure of the meatus produces a resonant column of air, which strengthens the sound. It is likewise probable that altered conditions of pressure and tension in the middle and internal ear play a certain part in causing the alteration, and also that sonorous vibrations, previously dispersed in the atmosphere, are conveyed through the finger to the bones, and thence to the sentient parts of the internal ear.

The symptoms of concussion of the labyrinth resemble those of injury, but they generally come on suddenly and pass off after a time. When hæmorrhage takes place into the structures of the labyrinth, the impairment of hearing is developed, either slowly or rapidly, according to the extent of the lesion and the quantity of blood effused; other symptoms, as described by Ménière, are prone to supervene.

Prognosis.—This depends, first, upon the degree of the concussion; and, secondly, upon the absence or the co-existence of injury to the ear and adjacent parts. If total deafness has resulted from the shock, the prognosis is unfavourable, though recovery is not impossible. In some cases many months elapse before any improvement is noticed, and in others an opposite course is witnessed. Politzer* records an interesting case in which the hearing (which had been totally lost for many months as the result of concussion) was suddenly restored. The patient, a man aged twenty-one, had received a severe blow on the head when passing under a doorway. When he recovered from the shock, he complained of headache, noises in the ears, and deafness, which last became complete in the course of a month. No change took place during the ensuing ten months, and he then came under treatment. Improvement was regarded as impossible;

---

* *Lehrbuch der Ohrenheilkunde*, S. 526.

but the experiment was made of injecting a warm solution of iodide of potassium (2½ per cent.) into the meatus. On the third day, the patient could understand a few words spoken into his right ear; and a gradual though slight improvement took place during the next three weeks, when headache became troublesome. One night, shortly afterwards, the patient was roused from sleep by a sensation of giddiness, and he then found that he could hear the ticks of his watch. When examined on the following day, his hearing, tested by the watch and by conversation, was found to be normal. Whether the symptoms were due to concussion of the labyrinth or of the nerve-centres, must be regarded as doubtful; but the latter hypothesis would seem the more likely.

The above-mentioned case must be regarded as very exceptional; and, as a general rule, the longer the symptoms last the worse the prognosis. The prospect is, moreover, unfavourable whenever subjective sensations and giddiness are prominent symptoms, and especially when they are accompanied by abnormal acuteness of hearing. It is impossible to forecast the duration of the symptoms, for even in cases of slight concussion they may remain unaltered for many months.

Treatment.—Rest, bodily and mental, is the most important agent in the treatment of concussion of the internal ear. In strong, full-blooded subjects, with signs of cerebral congestion, leeches may be applied to the mastoid process, or a blister to the nape of the neck. The bowels should be kept freely open, and the diet should be of a suitable character. When the symptoms have become chronic, tincture of iodine may be painted over the mastoid process, or blisters may be applied. A warm solution of iodide of potassium dropped into the meatus is worthy of trial. When noises in the ears are very troublesome, a course of the bromides is likely to prove beneficial.

INJURIES TO THE LABYRINTH.

Owing to its protected and deep-seated position, the labyrinth alone is seldom, if ever, the seat of injury; but it may, of course, be implicated in wounds of adjacent parts. Thus the internal ear may be affected in fractures of the temporal bone, the result of blows or falls; it may also be wounded by foreign bodies, instruments, etc., introduced into the external meatus. Severe concussions may likewise cause rupture of the membranous structures, or even fracture of the osseous walls of the labyrinth.

The structures of the internal ear are liable to be involved in ulcerative processes, affecting its osseous walls, the fenestræ, or the semicircular canals. Suppuration sometimes extends from other parts along the connective tissue and vessels of the labyrinth; and purulent inflammation of the middle ear has been known to extend to the same part through the fenestræ.

Gruber relates the case of a man who had been working for several hours in a caisson, and on coming into the open air became giddy, and vomited. These symptoms soon passed off, but the man was noticed to be deaf on both sides. On examining the ears, there was found to be rupture of both tympanic membranes, and the symptoms pointed to injury and extravasation of blood into the internal ear on both sides. The membranes cicatrised, but the deafness still remained two years after the accident. It is worthy of note that in cases of injury from falls or blows, the membrana tympani may be unaffected, even though the petrous portion of the temporal bone be seriously fractured. The escape of cerebro-spinal fluid from the meatus is generally regarded as a symptom of fracture of the base of the skull; but this symptom is not always present, for the membrane, as just mentioned, may be intact and prevent the flow. On the other hand, in some cases the extravasated blood rapidly coagulates between the surfaces of the fracture; in others, the portions of bone remain in close apposition, and, under such circumstances, the fluid will be prevented from escaping into the meatus, even if there be a large rent in the membrane (see page 637 *et seq.*).

When blood is extravasated among the tissues of the internal ear, and the patient survives, it undergoes the same changes as in other parts of the body. The fluid portion is absorbed, and in the course of time deposits of pigment are all that remain. The extravasated matters may, however, be the cause of inflammation, with more or less destruction, of the internal ear.

Extravasation of blood into the labyrinth may occur in the absence of any external injury to the part. The labyrinth may be affected in cases of meningitis, and especially in hæmorrhagic pachymeningitis. In cases of this latter character, Moos found hæmorrhagic infiltrations in various parts of the labyrinth, viz., in the utricle, in Rosenthal's canal, and between the layers of the *lamina spiralis ossea* and the *zona dentata*. In the case of a boy, aged four, who became totally deaf in the course of tuberculous basilar meningitis, Lucae found evidences of hæmorrhagic inflammation in the semicircular canals and vestibule on both sides.

Symptoms.—The symptoms of injuries of the labyrinth are for the most part the same as those of concussion. The loss of hearing may, however, come on later, as it may result from hæmorrhage rather than from shock. High notes especially fail to be heard, and sometimes a series of notes are inaudible. Some of the symptoms known as Ménière's are also likely to occur: these will be described in a succeeding chapter. In less severe cases, the patient may complain only of confusion and dulness of hearing, as if the meatus had become suddenly occluded, of tinnitus, and of the addition of a metallic ringing echo to ordinary sounds.

The **Diagnosis** of injuries of the labyrinth is made by considering the symptoms and the nature of the injury. If there be pronounced deafness on the affected side, and the tuning-fork, applied to the skull, be not heard, it may be regarded as certain that the labyrinth is involved. Sometimes the diagnosis can be made only *per viam exclusionis.*

The **Prognosis** likewise depends upon the symptoms, the nature of the injury, and the existence of complications. In total deafness, due to injury of the labyrinth, the chance of restoration is very slight indeed.

The **Treatment** is much the same as that recommended for concussion of the internal ear, complete rest being the all-important detail. Such local measures as syringing the meatus and the use of the air-douche are to be avoided; they are almost certain to aggravate the symptoms. If there be much local pain, a few leeches should be applied to the mastoid process; while troublesome subjective symptoms may be relieved by the bromides. When all active symptoms have subsided, and the deafness alone remains, the iodide of potassium may be given with the view of promoting absorption, and for the same purpose counter-irritation may be applied behind the ear.

CHAPTER XLII.

CARIES AND NECROSIS OF THE LABYRINTH.

Caries of the Labyrinth as a Result of Extension—Necrosis of the Labyrinth—Causes—Symptoms, as Otorrhœa, Pain, Polypous Growths, Disorders of Equilibrium, Subjective Sensations, Loss of Hearing-Power, and Facial Paralysis—Forms of Sequestra—Prognosis—Treatment.

Caries of the Labyrinth is always associated with a similar affection of the adjacent parts of the internal ear; no case in which the labyrinth alone was thus diseased has yet been recorded. Minute apertures are sometimes found in the osseous semicircular canals; but these, in the absence of symptoms of inflammation, are to be regarded as dehiscences, and not as the result of caries.

Necrosis of the Labyrinth, as an independent affection, is not very rare. It generally results from purulent inflammation of the middle ear, the process extending from the tympanum and mastoid cells to the air-spaces in the osseous walls of the labyrinth. The inflammatory process in the middle and internal ear is not only prejudicial to the organ itself and the adjacent structures (particularly to the facial nerve in the temporal bone), but the attendant suppuration, which may continue for weeks or months, is a source of considerable danger. Toynbee drew attention to the relatively somewhat common occurrence of partial or total necrosis of the labyrinth, and Bezold,* of Munich, has collected some forty-five instances of exfoliation of this part in the living subject.

---

* *Archives of Otology*, vol. xvi. p. 297. See also Report of Case of Necrosis of the Cochlea, by Dr. Hartmann, in the same vol., p. 252.

Causes.—In nearly half the number of cases referred to, the patients were under fifteen years of age when the sequestrum was removed from the ear; the age at which the inflammatory process commenced could seldom be ascertained. The first decade of life furnishes the largest proportion of patients. This proclivity is, no doubt, due to the frequent occurrence of catarrhal and suppurative processes of the middle ear at that period of life, and particularly of the more severe forms resulting from the acute exanthemata. In children, also, the labyrinth is proportionately much larger than in the adult; for at birth this part has already attained nearly its normal development. In many of the cases the commencement of suppuration dated from an attack of scarlatina; while measles was the cause in a smaller number. The acute suppuration in the middle ear does not necessarily attack the labyrinth at the same time; the process usually extends to it after an uncertain interval. In thirty-eight cases, only two lasted less than a year before exfoliation of the sequestrum; the rest of the patients had a discharge for periods varying from one to forty years before separation took place. The necrosis of the internal ear is frequently accompanied by destructive disease of the mastoid portion, resulting in fistulous openings in its external wall. There is no reason for supposing that any peculiar diathesis is a predisposing cause of necrosis of the labyrinth.

Symptoms.—Otorrhœa is, of course, present, the discharge varying in quantity, but being profuse and continuous while the necrosis is advancing, and until the sequestrum has separated. The other symptoms are (1) more or less pain, (2) the formation of polypous growths, (3) disturbances of equilibrium, (4) subjective sensations, (5) loss of hearing-power, and (6) facial paralysis. Symptoms due to implication of the cranial contents are not infrequent.

The *pain* involves the side of the head, and sometimes extends to the other side; mastoid tenderness is occasionally present. The pain is due at first to the inflammatory process; and in later stages to the separation and passage of the sequestrum. When this latter process is taking place, the pain is apt to be continuous and violent; and the patient wears a characteristically anxious expression. The loss of sleep induces much disturbance of nutrition, and the patient becomes pale and thin: but these symptoms rapidly subside after the sequestrum has come away. Rigors and febrile attacks are not uncommon during the course of the process. *Polypous growths* are invariably present: they are most abundant in the tympanum, on the edges of the membrana tympani, and in the external meatus: in some cases they are found in the Eustachian tube. They may completely fill the auditory canal, and they continue to sprout so long as the sequestrum lies imbedded behind them. After the latter has separated, most of them spontaneously disappear.

Disturbances of equilibrium were noticed in a few cases, but mostly in the early stages, and not continuing throughout the progress of the disorder. In twenty-three of the cases alluded to, no such symptom was experienced, and it is certain that vertigo is not regularly present as an initial symptom of necrosis of the labyrinth. Its existence indicates the extension of the suppurative process from the middle to the internal ear. Moreover, when present, it may be owing to cerebral and meningeal complications. After exfoliation of the sequestrum, any disturbance of equilibrium must be due to continued irritation of the centre.

It is somewhat curious that *subjective sounds* are seldom complained of in cases of necrosis of the labyrinth; they were present in only three cases. Their frequent absence seems to prove that the part in which they originate is more easily destroyed than the terminal distribution of the vestibular branches in the ampullæ, whose irritation would seem to cause the vertigo and disturbance of equilibrium.

The loss of hearing-power varied considerably in different cases: in twenty-three, complete deafness was observed. In four, there seemed to be more or less capacity for hearing after exfoliation of the cochlea itself; but these results are in contradiction to a proportionately large number of other cases. Hearing is completely lost when the labyrinth is destroyed. Bezold points out that one of the principal sources of error in our tests of hearing is the difficulty and partial impossibility of completely excluding the other ear from receiving any sonorous impressions. It is very difficult to occlude the meatus thoroughly, and the least chink is sufficient to allow the passage of the waves of sound. The tuning-fork is the most efficient means of testing the hearing in these cases. When a very weak sound is given off, the other ear may be left out of consideration; with low-pitched tuning-forks it is hardly necessary to close it.

The facial nerve is intimately connected with the labyrinth, and is generally involved when the latter is the seat of inflammatory processes. Paresis or paralysis of this nerve is a constant result of exfoliation of the cochlea; the loss of function may be due to pressure, and may be only temporary; but the nerve may be partially or entirely destroyed, and in that case the paralysis is likely to be permanent. In thirty-five of the cases above alluded to, the facial nerve was partially affected in six instances; in three of these the necrosis was limited to the cochlea; in one, to the cochlea and a small part of the vestibule; in a fifth, to the semicircular canals; and in the sixth, there was extensive caries of the labyrinth with exfoliation of the lamina spiralis. In twenty-eight of the cases there was decided paralysis of the nerve. This frequent participation of the facial, which is one of the most common symptoms of necrosis of the labyrinth, is due to the intimate connection between the latter part and the aquæductus Fallopii. The course of the facial nerve may be divided into four parts, and the implication of each of these in exfoliation of the labyrinth leads to entirely different sequelæ. In the first part of its course, within the internal meatus, it is liable to be affected in cases of exfoliation of the entire labyrinth, and the result is permanent loss of function, either partial or complete, of the facial, as well as of the auditory nerve. In the second part of its course, which extends from the beginning of the aqueduct to the geniculate ganglion, the nerve is not so liable to be involved; but in the third section it is in more danger, especially if the osseous vestibular walls be necrosed. In the fourth part of its course the nerve is seldom exposed to primary destruction by necrosis of the labyrinth; but it may be affected secondarily, especially when the sequestrum escapes into the mastoid antrum. In some cases, paralysis of the nerve is due to pressure of the granulations surrounding the sequestrum.

Paralysis of the facial nerve, of a temporary character, sometimes complicates middle-ear suppuration; it is said to occur in about one per cent. of such cases. It is seldom, if ever, noticed in simple non-purulent, acute middle-ear catarrh. Bezold says it down as a rule that in every case of facial paralysis accompanying long-continued suppuration of the middle ear, we are justified in excluding superficial disease, and in assuming the existence of extensive destruction of the bone, in most instances of the labyrinth. It must not be forgotten that the facial, like other nerves, possesses considerable regenerative capacity. In six of the cases alluded to there was no doubt as to the partial or total restoration of the function of the facial, in spite of its division. In one such case, the sequestrum consisted of the whole of the labyrinth; and, judging from the results of several others, we may anticipate, under very favourable circumstances, complete restoration, not only in simple division, but also where there has been a considerable loss of substance of the facial nerve.

As might be expected, the *chorda tympani* is much more often injured than the facial nerve in cases of necrosis of the labyrinth, and it is equally capable of regeneration. The large superficial petrosal nerve is very rarely implicated.

The *sequestra* vary much in size and character. Thus, there may be (1) necrosis of the entire labyrinth, and of the wall of the internal meatus; (2) necrosis and exfoliation of the cochlea, with other portions of the petrous bone; (3) the cochlea alone or only a portion of it; (4) a semicircular canal; (5) the pars petrosa, with the external canal and a portion of the mastoid process, etc.

Prognosis.—Death occurred in 19·6 per cent. of Bezold's cases, and in the majority from implication of the neighbouring meningeal and cerebral regions, extension of the suppurative process taking place from the posterior surface of the bone corresponding to the position of the internal meatus. The cerebellum was most frequently involved. In the thirty-seven cases, the terminations were as follows: in twenty-nine the sequestrum was removed through the auditory canal; in seven, through the mastoid process, previous artificial widening of the openings being necessary in some of the cases. In one instance the sequestrum passed through the Eustachian tube. Cessation of the discharge in a few weeks or months took place in eighteen of the cured cases. Notwithstanding the dangerous proximity of the suppuration to important parts, the long duration of the process, with its dangers to the constitution, and the obstacles to the elimination of the sequestrum, the prognosis would appear to be remarkably good, so far as recovery is concerned. Moreover, even where there has been extensive loss of substance of the facial nerve, there is a probability of complete restoration of the function.

Treatment.—The most important result to be attained is the removal of the luxuriant growths which obstruct the passage of the sequestrum through the tympanum and external meatus. These granulations must be removed by a curette or Wilde's snare, or destroyed with a concentrated solution of chromic acid, according to their size and position. When the sequestrum has come away, the application of alcohol or boric acid will serve to check secretion and to reduce the size of any remaining granulations. When the mastoid process is implicated, it is desirable to make an opening as soon as possible, so that secretion, etc., may escape. Any existing fistulous openings should be enlarged; and, if a sequestrum be found, it should then be removed. With large sequestra, it may be necessary to cut away the posterior wall of the external meatus, and in such a case it will be desirable to line the cavity with epithelium, as described in Chapter XXXIII. In the after-treatment, the wound should be frequently washed out with a solution of carbolic acid (one per cent.), and subsequently covered with an iodoform or other antiseptic gauze. The introduction of a drainage-tube will facilitate the escape of the discharge.

CHAPTER XLIII.

NEW FORMATIONS IN THE LABYRINTH AND CONNECTED WITH THE AUDITORY NERVE—SYPHILIS OF THE LABYRINTH.

Primary and Secondary Growths—Epithelioma—Sarcoma and Glioma—Cases of Fibro-Sarcoma—Cavernous Angioma—Syphilitic Disease of the Internal Ear—Morbid Appearances—Symptoms—Diagnosis—Prognosis—Treatment.

THE labyrinth is very rarely the seat of new formations of a primary character; it is sometimes invaded by morbid growths originating in neighbouring parts. Tumours are occasionally found connected with the trunk of the auditory nerve; Virchow states that of all the cerebral nerves the auditory is the most liable to be thus affected.

In the labyrinth new formations of connective tissue, in the form of minute threads and membrane, have been found by Gruber* and Voltolini.† Moos and others have met with bony growths in the vestibule and scala of the cochlea. Calcareous deposits have likewise been found in the periosteum of the internal meatus. These are composed of phosphate of lime, and are said to be not uncommon after middle life. Gruber describes a case in which he found chalky deposits in the cochlea and semicircular canals.

New formations originating in other parts and involving the labyrinth are always of a malignant character, and belong either to the epitheliomatous or sarcomatous class. A case of secondary epithelioma of the cochlea has been described by Politzer.[*] When first seen, the patient, a man aged forty-seven, had an ulcerating growth the size of a nut behind the right ear, and cancerous masses projecting from the meatus. The growth behind the ear rapidly increased, the ulceration spread, and in the course of a few weeks the patient died with symptoms of cerebral compression. On post-mortem examination, the apex of the cochlea was found to have been destroyed by the cancerous growth, the lamina spiralis in the second and third coils was broken through in places, and masses of cancer cells occupied the scala tympani and scala vestibuli. The elements of Corti's organ were infiltrated with many cancer cells.

---

* *Lehrbuch der Ohrenheilkunde*, S. 620.

† *Virchow's Archiv*, Bd. xviii.

In another and more numerous class of cases the growth commences in the cranial cavity, and extends thence to the auditory nerve or labyrinth. Formations of this kind are usually of a sarcomatous or fibro-sarcomatous character; a case of cavernous angioma of the petrous bone, implicating the auditory nerve, has been described by Politzer; and one of glioma, by Brückner.[†]

Mr. Field[‡] has recorded a case of sarcoma involving the auditory nerve on the right side. The tumour sprang from the internal auditory meatus, originating apparently from the dura mater lining the canal, and ensheathing the auditory nerve. The growth was as large as a Maltese orange, and was attached to the bone just above the internal meatus; its surface was fissured and corrugated, and its structure on section not unlike cerebral tissue. Microscopical examination proved it to be a round-celled sarcoma, abounding in vessels; it appeared to have grown with a moderate degree of rapidity. The symptoms during life were pain in the head, vomiting, deafness on both sides, marked paralysis of right side of face, and impairment of power in right limbs. There was also double optic neuritis with consecutive atrophy. All the symptoms pointed to a cerebral tumour as their probable cause.

In another case, reported by Burckhardt-Merian, a fibro-sarcoma of the dura mater involved the labyrinth. It originated close to the jugular fossa, where it divided into two branches, one entering the vestibule as a round cord through the enlarged aquæductus cochleæ, the other passed under the floor of the internal meatus, partly encircling the necrosed cochlea, to the tunica adventitia of the carotid artery.

---

[*] *Lehrbuch der Ohrenheilkunde*, S. 509.

[†] *Berlin. Klin. Woch.*, 1867, Nr. 29.

[‡] *Diseases of the Ear*, p. 271.

Dr. Moos has recorded a case in which a round spindle-celled sarcoma was found on the outer side of the left internal meatus; the auditory nerve entered the tumour and could be followed for only a very short distance. The symptoms were headache, vertigo, deafness, anæsthesia of the left side of the face, and ptosis. A case of sarcoma of the cerebellum, involving the auditory nerve, is described in detail by Dr. Stevens.* The tumour occupied half of the right side of the cerebellum, and a portion projected into the internal meatus. The connection between the peripheral and central fibres of the nerve was lost in the tumour. The symptoms had been total deafness on the left side, dulness of hearing on the right, imbecility, unsteady gait, drawling speech, and pain in the left side of the forehead and occiput, with a comatose condition lasting for a month before death.

A remarkable case of tumour of both auditory nerves is recorded by Dr. C. H. Burnett. The patient, a woman forty-two years of age, had suffered from deafness, tinnitus aurium, unsteadiness in gait, pain in the limbs, impairment of sensation in the legs, vertigo, and nausea. Some weeks before death there was loss of power over the legs, and inability to rise from bed; both optic discs became indistinct in outline. After death a large tumour was found pressing on the left half of the pons, crus cerebri, and left hemisphere of the cerebellum. "The seventh nerve wound inward, forward, and then downward round the tumour, to which it was tightly adherent, and by which it was flattened into a ribbon-like band, appearing transparent. The tumour extended with the left nerve into the left internal auditory meatus, and after removing the brain a second tumour was found on the posterior surface of the right petrous bone. This had, as on the other side, considerably enlarged the internal auditory meatus. On a minute examination of the internal ear no trace could be found on either side of Corti's organ."

In the case of glioma, described by Brückner, the tumour had completely obliterated the auditory nerve on the left side. The symptoms noticed during life were uncertainty in the movements of the upper and lower limbs, deafness on the left side, giddiness, and catarrh of the middle ear. A whirring sound was sometimes audible on applying the ear to the patient's left temple.

---

* *Zeitschrift f. Ohrenheilkunde*, Bd. viii.

Politzer's case of cavernous angioma of the temporal bone would appear to be unique. The patient, a girl aged twelve, had suffered for a year and a-half from otorrhœa and periodical hæmorrhages from the right ear: facial paralysis had existed for several weeks. On admission a bluish-red polypoid growth, bleeding profusely on the slightest touch, was found to occupy the inner half of the meatus; there was deafness on the affected side and increased perception of sound through the bones. Removal of the polypus with a snare was followed by very profuse bleeding, and the growth rapidly recurred in spite of repeated operations. The facial paralysis and some roughness of the bone on the posterior wall of the meatus indicated the presence of a carious process in the bone, complicated by the polypi. Two months afterwards death occurred with symptoms of suffocation. On post-mortem examination, openings, partly filled up by small, ragged growths, were found in the membrana tympani and posterior wall of the meatus. At the base of the skull there was an irregular, tuberculated, ovoid tumour, as large as an orange, projecting forwards into the right middle cranial fossa, and backwards into the posterior fossa. The growth was partly osseous and partly spongy in texture. Its base was formed by the superior and posterior pyramidal surfaces and the inner surface of the mastoid portion. On a section through the petrous bone, the osseous mass of the pyramid was seen to be traversed by numerous small and large cavities, with round excrescences growing from their walls. From the upper section of the pyramid grew a radiating osseous framework, composed of lamellæ and large cavernous compartments. The polypus was also found to be a cavernous angioma, connected with the growth in the petrous bone, and containing osseous trabeculæ. The starting-point of the tumour was the lateral sinus, which communicated with the cavities of the angioma.

SYPHILITIC AFFECTIONS OF THE INTERNAL EAR.

As a result of acquired syphilis, the internal ear is somew more frequently affected than the tympanum; and the lesio which occur in it are apt to cause very grave impairment hearing-power. There is abundant reason for believing that form of deafness, generally complete, is sometimes connect with the acquired disease, but far more frequently with inherited form. In both cases the symptoms probably depe upon similar changes, either in the nervous structures or other parts of the internal ear.

In cases of the acquired disease, the period at which symptoms occur varies considerably. Sometimes they sh themselves simultaneously with the eruption on the skin or the throat; in other cases, they appear many years after primary infection, and when other traces of the disease ha apparently subsided. Sometimes they are superadded to an o standing affection of the middle ear, of non-specific origin.

Very little is known as to the nature of the changes whi take place in the affected structures; but from the rapidi with which the symptoms are sometimes developed, it may supposed that, in such cases, exudation of plastic material tak place in the labyrinth. In chronic cases, post-mortem examin tion has discovered thickening of the periosteum of the vestibu calcareous deposits, immobility of the stapes, round-cell infiltr tion between the membranous and osseous labyrinth, amo Corti's rods and cells, and in the ampullæ and semicircu canals. In a case recorded by Moos and Steinbrügge,* deafness resulting from tertiary syphilis, there was enlargeme of the cells in the temporal bone, and in the capsule of t labyrinth, with hæmorrhage and development of connective tissu infiltrated with small cells. Blood was effused between the fibr of the auditory nerve and in the cochlea. Politzer has notic degeneration of the ganglion cells in Rosenthal's canal (*canal spiralis modioli*).

The **Symptoms** are more or less marked deafness, tinnitus, an pain in the ear and side of the head; giddiness and defecti balancing power are present in some cases. In unilateral diseas the vertigo may be very severe; and when both sides are affected, the patient may not be able to walk a few yards without staggering. The tinnitus is seldom absent, and is liable to come on suddenly as the first symptom. The kind of noise varies in different cases, and also at different times in the same case.

---

* *Zeitschrift f. Ohrenheilkunde*, Bd. xiv.

The deafness comes on with or after the tinnitus; it is generally severe from the first, and rapidly increases. Both ears are usually affected, one perhaps more than the other; the loss is seldom unilateral. Inflation of the middle ear makes little or no difference in the hearing-power. The impairment of bone-conduction is early and marked, and the deafness soon becomes complete; when one side only is affected, the tuning-fork is heard by the normal ear. When there is severe impairment, Rinne's test gives positive results. It would seem that in most cases of syphilitic disease of the labyrinth, the power of appreciating low notes is the last to become affected and the first to be recovered: hence the probability that the cochlea is the seat of the disease.

The objective symptoms vary, according as lesions of the membrana tympani or throat are present or absent. Whitish, well-defined patches, dotted over the membrane, have been sometimes noticed. Mucous patches, or perhaps superficial ulceration in the fauces and neighbouring parts, with general congestion of the throat, involving the naso-pharynx and the mouths of the Eustachian tubes, are likely to be present if the disease occur in connection with the secondary stage of syphilis.

Pain, when present, varies as to locality, being felt in some cases in the side of the head, and in others about the eyes. Sometimes there is severe nocturnal bony pain in the scalp; and this is likely to be present when the aural complication occurs during the latter part of the secondary stage. Under such circumstances the complaint is analogous to iritis and neuro-retinitis, the result of acquired disease.

Mr. Hutchinson points out that when the ear-affection is due to an *inherited* taint, severe deafness is seldom noticed till the patient is eight years old. It usually occurs at a later period and is accompanied by keratitis, whereas iritis is an earlier symptom. In this class of cases total deafness is very liable to ensue, and the disease is a frequent cause of acquired deaf-mutism. Mr. Laidlaw Purves* states that in cases du to congenital syphilis, the deafness generally comes on in th interval from five years before to five years after puberty usually following interstitial keratitis. Two-thirds of th patients are females. Deafness is generally the only symptom; but there is sometimes vertigo and tinnitus. As a rule, discharge is absent, and dryness and opacity of th tympanic membrane are the only objective changes that ca be detected. The late Mr. Hinton stated that one in twenty of his patients suffered from inherited syphilis, and that i was by far the most common cause of non-congenital deaf-mutism. Sir William Dalby places it next to scarlet feve as a cause of that condition, and he states that the most genera time at which the aural affection shows itself is from five t fifteen years of age; the earliest age at which he has seen i being five, and the latest twenty-three years. The change found in the ears *post mortem* consist of suppuration in th tympanum; thickening of the membrane and adhesion between it and the promontory; hyperæmia and hæmorrhag in the labyrinth; pus cells in the vestibule, and disintegratio of Corti's organ. According to Mr. Laidlaw Purves, the pathological changes are those of a chronic periostitis, leading to a gradual and more or less complete occlusion of the cavities o the internal auditory meatus and bony labyrinth, with consequent injury or destruction of the delicate soft structures i these situations. Hereditary syphilis of the labyrinth is ofte accompanied by middle-ear catarrh, suppurative inflammatio or adhesive processes, interstitial keratitis, and the peculiarl notched teeth described by Mr. Hutchinson.

Messrs. Urban Pritchard and Cheatle† think that cases of inherited syphilitic deafness may be divided into two classes, differing from each other in the mode of onset. In the first, the deafnes sets in without giddiness, the mechanism for equilibration being apparently left intact. The symptoms take either a subacute or a chronic course. In the second form, the deafness is accompanied by giddiness; and the symptoms may run an acute, subacute, or chronic course. The whole of the labyrinthine nerve-endings are more or less seriously implicated, as a result of increased tension.

---

* *Guy's Hospital Gazette*, June 7, 1897.

† *Archives of Otology*, vol. xxvii. p. 415.

Labyrinthine affections connected with acquired syphilis usually run a rapid course, the loss of hearing-power sometimes becoming complete in the course of a few days. In other cases the deafness is more gradually developed, and remains for some time stationary after reaching a certain degree, and then becomes aggravated. Slight injuries to the head have a very unfavourable influence on the course of the disease. The deafness once fully developed is not liable to alterations; and any improvement that may take place is usually very gradual in its progress.

The **Diagnosis** will be determined by the history of the case and the nature of any co-existing symptoms. The suddenness with which the tinnitus, giddiness, and deafness usually come on, and the early loss of bone-conduction, are important features in the complaint. The loss of hearing is likewise symmetrical, and the middle ear is often found to be healthy. If there be at the same time evidences of syphilitic infection—*e.g.*, a characteristic eruption, enlarged inguinal or cervical glands—there can be little doubt as to the nature of the aural disease. When, as sometimes happens, the deafness supervenes gradually, and many years after the primary infection, and there are no evidences of syphilis, the determination of the true nature of the case may prove very difficult. The results of treatment may, however, supply some information,

Prognosis.—This, as a general rule, is decidedly unfavourable; but it varies with the patient's condition and with the duration of the symptoms. The deafness is likely to be permanent in cases of acquired syphilis when the patient is middle-aged, and has become much reduced, and likewise suffers from congestion of the throat and closure of the Eustachian tubes. In young subjects, on the other hand, of good constitutions, and coming early under treatment, the prognosis is more favourable. In the hereditary form, little, if any, benefit can be anticipated from treatment.

Treatment.—The patient, if young and in fair health, should at once be put upon a course of mercury and iodide of potassium. One grain of blue pill or of mercury with chalk may be given twice or three times a day, the results being carefully watched. The addition of a grain of reduced iron is often beneficial (see page 221). Salivation must, of course, be avoided, if possible. If no improvement take place after three or four weeks, the dose of iodide of potassium should be gradually increased, until a drachm or more is taken daily. In old-standing cases, a combination of mercury with iodine will sometimes prove more efficacious than either drug alone. Improvement will be indicated by increase of hearing-power and of bone-conduction.

For recent cases Politzer recommends the subcutaneous injection of from four to twelve drops daily of a 2 per cent. solution of pilocarpine. He states that he has obtained very good results from this treatment, and advises its adoption in the cases specified. If no improvement be discoverable in from eight to fourteen days, mercury must be prescribed. He likewise recommends such local treatment as injections into the meatus of solutions of the iodide of potassium, and the application of iodoform or mercurial ointment behind the ear. Warm baths and the internal administration of iodine and sulphur waters are, he states, valuable adjuncts to other kinds of treatment.

The author is strongly of opinion that mercury should be administered in *all* cases of syphilis, irrespective of the stage, and that iodide of potassium should be given *in addition* as long as the so-called secondary symptoms are present, and in the later stages of the disease.

As a subsidiary measure it is well to guard the patient's ears from the irritation produced by sounds and noises of various kinds. Relief is not infrequently obtained by a change of residence to some quiet seaside or country place. For the effective treatment of some aural diseases, it is just as necessary to protect the ears from loud or continuous sounds as to keep the eyes from the effect of light in many diseases of these organs.

CHAPTER XLIV.

MÉNIÈRE'S GROUP OF SYMPTOMS.

Ménière's Account of his First Case—Phenomena of the Attacks and Consequences—Pathology—Flourens' and Crum Brown's Experiments—Sir S. Wilks' View—Drs. Woakes' and Gruber's Theories—Effects of Intra-Labyrinthine Tension—Prof. Steiner's Experiments—Diagnosis—Prognosis—Treatment.

AFFECTIONS of the labyrinth often give rise to disorders of hearing, noises in the ears, giddiness, unsteady gait, and nausea; and these symptoms more frequently occur in combination than singly, though sometimes one and sometimes another predominates over the rest. Impairment or even loss of hearing-power, accompanied by the other symptoms above mentioned, may come on suddenly, and so far resemble an attack of apoplexy; and doubtless many such cases have been regarded as due to cerebral or meningeal disease. The connection between these symptoms and lesions of the internal ear was first suggested by Ménière,* who met with a case in which deafness, giddiness, and vomiting suddenly came on, and death ensued on the fifth day. The patient was a young girl who had been exposed to cold during a catamenial period. On post-mortem examination nothing abnormal was found in the brain or spinal cord; but the semicircular canals were filled with a reddish plastic material, which extended into a portion of the vestibule, but was absent from the cochlea. This and other similar cases induced Ménière to believe that the attack was due to a peculiar lesion of the labyrinth, in which the sudden effusion of blood, or other fluid, produced symptoms akin to those caused in animals by injuries to the semicircular canals.. Ménière did not merely wish to draw attention to the fact that vertigo was a common symptom in patients suffering from deafness or from some disease of the organ of hearing. His object was to show that sudden, apoplectiform symptoms, including at least a transient form of unconsciousness, giddiness, vomiting, and tinnitus, might occur in a person previously healthy, and be followed by deafness, and that disease of the internal ear might be the cause of all the symptoms.

---

* "Mémoire sur les lésions de l'oreille interne donnant lieu à des symptômes de congestion cérébrale apoplectiforme."—*Gazette Méd. de Paris*, 1861, p. 598.

The **Phenomena** characteristic of Ménière's disease are as follows:—Without obvious cause, a person suddenly becomes conscious of noises in the ears, and feels giddy and sick; the expression is anxious and the face pale and often covered with perspiration; the power of hearing ordinary sounds is much impaired, or even altogether lost. Sometimes the patient falls to the ground, but without becoming unconscious. Charcot states that during the attack, "whatever may be its intensity, the patient absolutely preserves perfect consciousness of his actions," and that as soon as the first effects have passed off he is able to render, without hesitation, an account of all he has felt. Any apparent loss of consciousness is produced by the giddiness, and is only transient. The muscles are relaxed, and in some cases there is slight and temporary paresis of the arm and leg on one side; convulsions do not occur. The duration of the symptoms varies greatly; they may last only a few minutes, or may continue for several hours. After the attack is considered to be over, some amount of giddiness often remains; the patient walks with difficulty owing to loss of balancing-power. Seizures of a like character recur at varying intervals; in some patients they appear to assume an intermittent type, coming on at much the same hour. The impairment of hearing, generally affecting both sides, continues for an indefinite time, and is apt to be progressive, until total deafness results. When this latter stage has been reached, the attacks usually cease to trouble the patient; but there are exceptions to this rule. Mental depression is often a prominent symptom.

In some cases, the attacks are preceded by premonitory symptoms, such as noises in the ears, of various kinds, and these have been regarded as corresponding with the *aura* of epilepsy

On the other hand, cases occur in which the attack is preceded by a cessation of the *tinnitus*, which had previously been constant. Ocular symptoms, such as hemiopia, dilatation of the pupils, and *muscæ volitantes*, are sometimes observed during the attack.

The deafness presents several peculiarities; it may be complete or incomplete, or only the power of hearing certain sounds may be lost. When both ears are involved, perception through the bones of the skull is almost or altogether absent.

Pathology.—The exact causation of Ménière's group of symptoms is as yet far from clear; it is a matter of common experience that giddiness, faintness, and sickness may occur in connection with diseases of the middle and external ear, and may even be caused by foreign bodies in the meatus, by accumulations of cerumen, by syringing the ear, and during removal of polypi. Pressure on the stapes will cause marked giddiness. Paroxysmal vertigo is often associated with more or less deafness, buzzing, and singing in the ears. In most of these cases the external parts are free from disease; and the tuning-fork applied to the vertex is not heard on the affected side, and hence it may be inferred that the internal ear is the seat of the mischief. It has been suggested by some writers that the cause of the vertigo is disorder of the labyrinth. Pressure on the fenestra ovalis causes increased tension in the semicircular canals, and thus all cases of aural vertigo have been thought to be examples of Ménière's disease. The experiments of Flourens and Crum Brown show that artificial lesions of the semicircular canals give rise to disturbances of equilibrium, due to the feeling of giddiness; and the latter experimenter believes that the function of these canals is to furnish the impressions which form the chief basis of our knowledge as to the relations between our movements and those of surrounding objects. If the horizontal canal be divided, the head of an animal is turned alternately to the right and left. Injury to the posterior vertical canal causes an up-and-down movement, a nodding of the head, and the animal not infrequently falls forwards or backwards. Injury to the superior vertical canal causes similar movements of the head, and the animal tends to fall forwards. When all the canals are destroyed, various pendulum-like movements are performed, and standing is impossible. The movements are supposed to be reflex results of impressions conveyed to the co-ordinating centre for the various canals, which, under normal conditions, balance each other, but fail to do so when some canals are diseased or injured. The late Dr. Hilton Fagge* considered that the case recorded by Ménière himself was not satisfactory as a basis for the generally accepted theory, and that the explanation was improbable. It is generally assumed that in cases of this kind hæmorrhage takes place into the semicircular canals; but the blood must be effused on both sides, since the deafness is generally in both ears. In some cases also the cerebral symptoms come on suddenly, and as suddenly pass off.

Sir S. Wilks suggests a different view from that usually accepted as to the causation of Ménière's symptoms. He thinks that in cases in which there is no affection of the meatus or tympanum, both the deafness and cerebral symptoms are generally due to changes in the nervous centres. In Ménière's disease, strictly so-called, the sudden loss of hearing may be due to some affection of the auditory centre, and the giddiness to a similar affection of the centre for equilibrium, probably adjacent, since its most important afferent nerves come from the semicircular canals. The vertigo often presents marked peculiarities, supposed to depend upon affections of particular ampullæ, but these can all be referred to corresponding changes in the centre, in which the functions of each canal must necessarily be fully represented. In support of this view, Dr. Fagge adduced the analogy with other paroxysmal neuroses. Impairment of sight is frequent in migraine, and is due to affection of the brain and not of the eyes. In some recorded cases of Ménière's disease, cloudiness before the eyes and obscuration of the visual field were associated with the vertigo. The two neuroses may perhaps have been combined, the nerve-storm spreading beyond its usual limits and encroaching on the area concerned in migraine. In the apoplectiform cases described by Ménière, the disturbance was diffused over the hemispheres, and occasioned the loss of consciousness. Another argument, adduced by Dr. Fagge, in favour of Sir S. Wilks' view, is suggested by the fact that bromide of potassium is capable of removing giddiness and loss of hearing at the same time. In Mr. Hinton's cases of Ménière's disease, paroxysmal vertigo and sickness with transient deafness were all caused to recur by administering quinine, and removed by other treatment.

---

* *Text-Book of the Principles and Practice of Medicine*, vol. i. p. 769.

In some cases it was observed that the impairment of hearing was especially marked for certain musical tones, those of the middle octaves being distinctly perceived, while those of the lower and still more those of the higher octaves were heard very imperfectly. In some of Charcot's patients it was noticed that the vertigo and buzzing were complained of so long as the deafness was partial; but that those symptoms disappeared when the hearing was completely lost. But even if in these cases the internal ear is the part primarily affected, it does not follow that the same thing is true of the apoplectiform cases, or that the vertigo is anything but a neurosis. The same symptoms may be produced in many different ways, but are themselves always the direct result of one particular kind of nervous disturbance, just as migraine may be excited by a variety of causes.

Two other theories with regard to Ménière's disease require a brief notice. The first of these, advanced by Dr. Woakes, is to the effect that the symptoms are due to an affection of the inferior cervical ganglion of the sympathetic. This ganglion exercises an influence upon the vertebral artery, and therefore upon the vessels of the labyrinth; and it is also connected with the branches of the vagus. When the action of the ganglion is weakened, deafness, noises in the ears, and giddiness result from labyrinthine disorder, while nausea and vomiting are caused by implication of the vagus. Quinine and tobacco depress the action of the ganglion, while hydrobromic acid has an opposite effect.

Another theory, advanced by Professor Gruber,* refers Ménière's group of symptoms to pressure on the base of the brain by fluid passing through the aquæductus cochleæ and vestibuli. He considers that variations in the size of the *recessus Cotugnii*, in which the endolymphatic duct terminates, are principal factors in the causation of the symptoms. In different cases this *recessus* is found to be sometimes as large as a hazel-nut, and sometimes so small as to be scarcely perceptible. When the intra-labyrinthine tension is increased, the perilymph is first affected and yields to the pressure; fluid passes through the aquæductus cochleæ into the sub-arachnoid space, and if the movement be rapid, the effects of pressure are produced on the central nervous organs, the degree of irritation required to produce them being dependent upon individual peculiarities of the auditory organ and adjacent parts.

---

* *Lehrbuch der Ohrenheilkunde*, S. 613.

Still more serious objections to the ordinary theory of the function of the semicircular canals have been raised by Professor Steiner,* of Cologne, who experimented on sharks caught in the Bay of Naples. In these fish the canals are particularly well developed, and are superficially arranged beneath the skin and separated from the brain by a considerable mass of cartilage. They can, therefore, be laid bare without injury to other parts. When this has been done, and the canals excised and the wound closed, no disturbance of locomotion is seen when the fish is replaced in the water. But if, after laying bare the labyrinth, the auditory nerve, or the ossicles surrounding the same, are pulled or displaced, the result is always a disturbance in the form of rotatory or circular compulsory movements. The same effects can be produced by similar operations on frogs and lizards. In the higher vertebrates, the structures concerned are so complicated that other parts are necessarily injured in the experiments. Ménière's symptoms would appear to originate rather in lesions affecting the brain or its membranes, and, as Gruber supposes, causing increase of pressure.

There is no doubt that Ménière's group of symptoms may be caused by pathological processes in the brain, and especially in the cerebellum. Mistakes, however, can seldom arise if it be remembered that Ménière's symptoms include not only attacks of giddiness, but unmistakable disorders of hearing, which latter but rarely occur in cases of cerebellar disease. A mistake would be likely in a case similar to that described by Wolf,† in which, during two years, Ménière's symptoms had been present, in the form of attacks of giddiness, subjective auditory sensations, impairment of hearing, and deafness for certain notes on the left side. After these had continued for two and a half years, symptoms of cerebral disorder were superadded, in the form of dilatation of the pupil, ptosis, facial paralysis, and mental disturbance. The case was one of gummatous growth of the cerebellum, involving the amygdala on one side.

Cerebellar diseases are characterised by disorders of co-ordination, and especially by staggering when attempting to walk, and marked giddiness. The other symptoms—*e.g.*, the disorders of vision, the pain in the occiput, and disordered action of various motor nerves—are due to accessory complications, and, more or less directly, to pressure.

---

* *Deutsche Med. Woch.*, Nov. 21, 1889; *Brit. Med. Journ.*, April 5, 1890.

† *Zeitschrift f. Ohrenheilkunde*, Bd. viii. S. 380.

Diagnosis.—This is made by a careful observation of the symptoms, viz., the sudden attack of deafness or impairment of hearing, and the subjective sensations, and by noticing the absence of signs of paralysis of any other cerebral or spinal nerves. According to Ménière, the fact that the symptoms are confined to the organ of hearing excludes the possibility of a cerebral affection, for if there were any central lesion of the auditory nerve, other symptoms would make their appearance, inasmuch as other nerve-centres are very close to the origin of the nerve in question. But Politzer points out that in cases in which the attacks are preceded by tinnitus, sensations of pressure and fulness in the ears, giddiness and impairment of hearing, the diagnosis of Ménière's disease must not be made as a matter of course. Such symptoms are certainly suggestive, but they occur also in cerebral congestion, at the commencement of several diseases of the brain, and particularly in connection with cerebral tumours. It may be mentioned that disturbances of hearing are only exceptionally present in lesions of the cerebellum; they are due to accidental pressure upon some of the adjacent fibres of the auditory nerve.

If, on the other hand, the attacks, as already described, occur without prodromal symptoms and in a marked form—that is to say, if, in a person previously possessing normal hearing, noises in the ears and more or less deafness suddenly supervene, accompanied by giddiness and staggering, but no other signs of paralysis, and if the external parts of the ear, the membrane and Eustachian tube are found to be normal—the existence of an affection of the labyrinth may fairly be assumed. After some time the diagnosis may become very difficult; the loss of hearing may be due to rigidity of the ossicles, supervening after all symptoms of a severe tympanic affection have completely disappeared. Giddiness is a symptom of acute inflammation of the labyrinth; but it is then continuous, and fever is likewise more or less marked.

Prognosis.—This is decidedly unfavourable in cases in which months or years have elapsed since the hearing was lost. On the other hand, in recent cases, with only partial impairment, some improvement may be anticipated from treatment. Restoration of hearing-power, with freedom from further liability to attack, is, however, quite exceptional.

Treatment.—An attempt should be made to ascertain the condition of the ears, and the patient should be carefully examined in other respects. If there be indications of cerebral hyperæmia, leeches should be applied to the mastoid region, and an ice-bag to the head and mustard plasters to the calves of the legs; laxatives are generally indicated. The patient must, of course, be kept as quiet as possible; his symptoms, especially the giddiness, will cause him to adopt the recumbent posture, with the head raised. The diet should be restricted to light and non-stimulating articles.

Various remedies have been recommended for the relief of the symptoms, and good results are sometimes obtained from quinine and iodide of potassium. The former is given in daily doses of from five to fifteen grains; but its use requires care. Sometimes the giddiness is decidedly diminished after a few doses; but in other cases the symptoms are increased. If no good result be obtained after three or four days' treatment with quinine, the medicine should be discontinued. Gruber mentions a case which demonstrates the necessity of great care in the use of quinine in this affection. A woman, otherwise in good health, had suffered from chronic middle-ear suppuration for some years. Ménière's symptoms appeared in an acute form, and quinine was given in daily doses of fifteen grains. No improvement resulted; but on the third day symptoms of acute glaucoma supervened, for which iridectomy was performed. Reports differ as to the effect of quinine upon the blood-vessels.* As already stated, according to some authorities, the drug causes anæmia of the retinal vessels; while others assert that they have seen hyperæmia and extravasation follow its administration. Other experiments showed a reduction of the temperature in the external meatus, and no hyperæmia of the membrane, after the use of quinine. Its good effects upon Ménière's symptoms have been ascribed to its power of lowering the blood-pressure, and of producing anæmia of the labyrinth.

---

* See Dr. Brunner's paper in *Archives of Otology*, vol. xvii. p. 206.

The iodide of potassium should be given in daily quantities of from eight to fifteen grains, and continued for at least a month. It is, of course, especially indicated whenever there is a history of syphilis. If, in such a case, the symptoms continue unchecked, the dose should be gradually increased; and if no result be obtained, mercury should be cautiously administered. In non-syphilitic subjects, the bromide of potassium, combined with tincture of aconite, has been found beneficial.

In recent cases exhibiting Ménière's symptoms, good results may sometimes be obtained from the daily subcutaneous injection of pilocarpine, four to ten drops of a 2 per cent. solution, or the same quantity internally. Gruber recommends tincture of arnica internally, five drops with a little tincture of nux vomica, twice daily; the dose to be gradually increased until ten drops are taken, and the medicine is to be continued for several weeks. When the symptoms occur in women shortly after the menopause, leeches should be applied to the mastoid process, and laxatives should be given somewhat freely. In gouty subjects, colchicum and potash are indicated; and if there be much nervous excitement, the bromides may be tried in combination with belladonna.

Not much can be expected from local treatment, but Politzer recommends that, after the acute symptoms have subsided, either the pilocarpine solution, or eight to ten drops of a warm solution of iodide of potassium, should be injected into the tympanum with the catheter every other day for three or four weeks. In chronic cases, change of air and warm or tepid baths are likely to prove useful.

CHAPTER XLV.

NEUROSES OF THE AUDITORY NERVE.

Acoustic Hyperæsthesia—Various Forms—After-Sensations—Neuralgia of the Ear—Hyperacusis of Willis—Acoustic Anæsthesia—Deafness Caused by Occupations—Symptoms of Nervous Deafness—Paracusis Loci—Subjective Auditory Sensations—Peculiarities and Causes—Changes in the Middle and Internal Ear—Effects of Certain Drugs—Reflex Causes—Question as to State of Auditory Nerve—Variations in Sensations—Entotic Noises—Effects of Subjective Sensations—Noises produced in Throat—Peculiarities in Individuals—Prognosis—Treatment.

VARIOUS perversions of hearing are caused by disorders of the labyrinth and auditory nerve and acoustic centres, and the faculty of hearing may be increased, diminished, or altered in various ways. Subjective sensations, disorders of equilibrium, and disorders of the stomach are other symptoms of functional and organic disease of the nervous structures of the ear.

The hearing-power may be either increased or diminished; the degree of alteration varying considerably in different cases. Increase of power is exhibited in two forms: in one, there is abnormal acuteness of hearing; in the other, unpleasant or painful sensations are caused by sounds or noises. **Acoustic Hyperæsthesia,** or **Hyperacusia** in the strict sense, is a condition which may be manifested in several ways. (1) The acuteness is so great that sounds used for testing are heard at abnormally long distances; (2) sounds, previously inaudible, are clearly perceived; (3) exceedingly slight differences in the pitch can be readily distinguished. This last condition is often physiological; it may be observed in persons with highly trained ears, such as musicians, some of whom, by practice, can distinguish sounds differing no more than in the proportion of 10,000 10,001 vibrations. Hyperacusia of a pathological kind may associated with increased power of other special senses—*e.* sight, smell, etc.; and such instances are seen in somnambulis and in persons in a state of ecstasy. The hearing may abnormally acute for all tones and noises, or only for certa sounds. In some instances, persons can hear at great distanc sounds which to others are either indistinct or quite inaudib This condition is sometimes noticed in cerebral congestion, pr duced by stimulants, and in excitable persons, in the absence any other affection of the ear; sometimes it comes on aft subsidence of catarrh of the tubes and tympanum.

In acoustic hyperæsthesia, more or less painful sensations a caused in the ear by various tones or noises. Even in norm ears, such sensations are often caused by tones of high pitch; a instances of this kind are frequently seen in anæmic, nervo and excitable persons.

This auditory hyperæsthesia is sometimes the precursor deafness and of cerebral disorder; it has often been observed cerebro-spinal meningitis and after injuries to the head.* Wh associated with sleeplessness and irritability, it is an occasion precursor of apoplexy. It is sometimes noticed in the early sta of fevers, and during excitement from any cause; after the effec of chloroform have passed away, there is sometimes audito hyperæsthesia of a transient character. Sir T. Watson† recor a case of irregular cholera, in which auditory hyperæsthesia w very prominent a few hours before death. In certain phases sleep there is increased sensitiveness of the auditory nerve; Did says that this nerve is the last to go to sleep and the first awake. The same condition may be caused by over-exertion a by want of sleep; it is frequently noticed in neurasthenic co ditions and as a concomitant of migraine. It is often syn ptomatic of acute and chronic affections of the sound-conducti apparatus and of the labyrinth, and especially of the worst for of adhesive inflammation, the sensitiveness to sound being inverse ratio to the amount of hearing-power. Acoustic hype æsthesia may, indeed, co-exist with almost absolute deafness, a may then cause distress, spasmodic movements, confusion of ideas, and nervous excitement. The sensitiveness is sometimes remarkably displayed towards particular sounds—*e.g.*, the human voice; and when this peculiarity accompanies severe deafness, the use of a speaking-tube becomes impossible. Temporary hyperæsthesia has been observed after the removal of an obstacle to the conduction of sound—*e.g.*, a plug of wax. Unpleasant sensations may likewise be caused by sounds, in the absence of increased irritability of the auditory nerve. Instances of this kind are due to lesions of the sound-conducting apparatus. Thus, peripheral paralysis of the facial nerve involves the stapedius muscle, which counteracts the tensor tympani, and the result is increased tension of the membrane and loudness of sounds.

---

* A marked case, due to a blow on the head in a carriage accident, is corded by Dr. Macnaughton Jones. There was no loss of hearing-power. *Briti Medical Journal*, 1895, vol. ii. p. 1292.

† *Lectures on Principles and Practice of Physic*, vol. i. p. 136.

In a peculiar form of acoustic hyperæsthesia there is a long-continued after-sensation; sometimes this is so closely connected with the original tone that both appear to be continuous. There are also some after-sensations where a pause intervenes between the end of the objective and the beginning of the subjective tone. The latter may last for a considerable time; thus in a case of chronic middle-ear catarrh, recorded by Urbantschitsch, the notes of a piano were heard many hours after the music had stopped. The ticking of a watch is not infrequently heard several seconds after the instrument has been removed, and in one case recorded by the same author the sensation was prolonged for several minutes.

Neuralgia of the ear, properly so-called, must be distinguished from those conditions in which auditory sensations are accompanied by discomfort and pain (see p. 644). In nervous otalgia the pain comes on spontaneously, and is unaccompanied by any local changes in the auditory apparatus. The diagnosis is made chiefly *per viam exclusionis*. There is no abnormality in the function of hearing, and subjective sensations are absent. In such cases it is assumed that the neuralgia is located in certain branches of the third division of the fifth nerve, or in the tympanic plexus. It is sometimes cured by the extraction of carious teeth, and by the removal of neuromata from the neighbourhood of the ear.

In one form of auditory hyperæsthesia, the so-called *hyperacusis* of Willis, a definite sound is heard better during a noise. This condition was once supposed to be merely imaginary, or, at least, to be due to the general elevation of the voice which is spontaneously assumed during a noise; but it has a real existence. Those who are the subjects of this condition are found to hear the ticking of a watch better when travelling in a train, or when near machinery in action. The explanation of this phenomenon is not altogether clear; but, as a matter of fact, the perceptive power of the organ of hearing is increased by every appropriate stimulus, and the ear, after a time, becomes able to perceive the effects of vibrations, which alone would have been insufficient to excite it. According to another theory, the change is due to increased mobility of the ossicles and loosening of bands of connective tissue. The increase of power is temporary; after removal of the cause, the perceptive faculty relapses to its former state. The phenomenon occurs in persons with sound hearing, and in those who are more or less deaf. It is noticed that in proportion to the loss of power, the noise required to excite the nerve must be of corresponding intensity.

This form of hyperacusis is apt to be manifested only under certain conditions, and is not observed when the sound which stimulates the perceptive faculty produces only a weak effect. It would seem that different tests are required for hyperacusis in different cases, and that a noise which raises the perceptive faculty of one deaf person, or for one ear, is too intense for another, and may, indeed, have quite a contrary effect. Thus it occasionally happens that a deaf person hears conversation during a noise better than another with full hearing-power; in the latter case, the louder sound masks the voice altogether.

Acoustic Anæsthesia is a condition in which the function of the auditory nerve is impaired or abolished. The cause of the alteration may be either in the peripheral parts of the auditory apparatus, in the trunk of the nerve, or in the nervous centres; the exact localisation of the mischief is often very difficult and sometimes impossible. There is, for example, often much doubt as to the origin of unilateral or bilateral nervous deafness (either partial or complete), which is apt to come on after injuries to the skull (severe concussion, fracture at the base or posterior part), and when associated with symptoms of organic cerebral disorder, or with meningeal disease, especially cerebro-spinal meningitis. The same may be said of nervous deafness after acute infectious diseases, though such a sequela may generally be referred to meningeal complications. In such cases the aural affection is generally bilateral, and the prognosis is unfavourable. Little is known as to the origination of deafness in cases of neurasthenia or of the condition which underlies the impairment of hearing sometimes produced by lead and quinine. In the latter cases the loss of function is seldom very marked; subjective auditory sensations are generally much more prominent symptoms.

In cases of neurasthenia, disorders of hearing may be associated with hemianæsthesia and other evidences of nervous derangement, or may constitute the only symptom of perversion or loss of sensation. The disorder generally takes the form of anæsthesia, which may be either complete or incomplete, and may exist on one or both sides; it is often accompanied by subjective sensations of various kinds and degrees of intensity. Giddiness is seldom complained of, and, in cases of hemianæsthesia, evidences of middle-ear disease are usually absent; but the entrance of air into the tympanum is not felt, and touching the membrane causes no sensation.

When the acoustic anæsthesia occurs alone and affects only one ear, there is sometimes hyperæsthesia on the opposite side. This latter condition may precede the impairment of hearing, as in a case recorded by Dr. Fulton.* The anæsthesia is not infrequently accompanied by some slight lesion of the middle ear, discoverable only on careful examination, and not of itself sufficient to account for the impairment of function. Bone-conduction is usually more or less interfered with, and sometimes altogether abolished. The anæsthesia is liable to vary from day to day, and may entirely disappear during longer or shorter periods. It may be that on one day loud shouts are almost inaudible; whereas a few days later the tick of a watch is distinctly heard. Some patients assert that they cannot hear whispers, though other sounds are clearly distinguished.

In girls, auditory anæsthesia sometimes coincides with the first appearance of menstruation, and with disorders of this function. In a few cases of undoubted neurosis, escape of blood from the auditory meatus has been declared to occur during the menstrual periods. In connection with the alleged occurrence of this phenomenon, the following case would seem to deserve mention:—In May, 1893, a girl, aged twenty, was brought from a Home for Fallen Women to the Aural Department of the London Hospital, with the statement that she was liable to hæmorrhage from the auditory meatus on both sides. The matron, who accompanied her, told the author that the girl stated that she had been seduced and had left her child in the country. On subsequent examination, it was found that she had a virgin *os uteri*, and presented no signs whatever of having been pregnant. The membrana tympani and the deeper parts were quite normal, and the hæmorrhage was represented by dried blood in the outer part of the meatus. As there was no visible cause for the alleged bleeding from the ears, the patient was admitted into the hospital, and carefully watched. No bleeding could be detected while the girl was thus under observation. There was no doubt as to the falsity of the statement regarding the pregnancy, and a similar explanation of the aural hæmorrhage was most probable. Other cases may doubtless be explained in a like manner.

---

* *Archives of Otology*, vol. xiv. p. 111.

Anæsthesia of the auditory nerve is sometimes associated with loss or perversion of other special sensations—*e.g.*, of smell, taste, and vision, and with attacks of vertigo, headache, and epileptiform convulsions. Symptoms of this kind are not confined to females; they sometimes occur among boys and young men.

Under the heading of "Hysterical (so-called) and Functional Deafness,"* Sir W. Dalby has recorded the case of a young lady, aged twenty, who suddenly became deaf to all sound. The tone of her voice was not affected, and the external and middle ear were quite healthy. On being tested in several ways, she never evinced the faintest perception or gave the slightest start. Six months afterwards, she came down to breakfast with her hearing quite restored.

The diagnosis is for the most part easily made, inasmuch as other and more common symptoms of neurasthenia generally co-exist. The suddenness with which the deafness is apt to come on and pass off would disprove the existence of organic lesions. Excitement and fatigue usually aggravate the deafness, while the opposite effect is produced by rest and tonic treatment of various kinds.

---

* *British Medical Journal*, 1895, vol. i. p. 574. See also a case by Dr. Ransom in the same volume, p. 470. The patient, a lad aged nineteen, became suddenly deaf and dumb.

General and severe debility, due to a great variety of causes, is sometimes attended by loss or impairment of hearing-power. Thus patients convalescing from pneumonia and intermittent fevers are sometimes more or less deaf until their strength has become established. Sexual excesses and the immoderate use of alcohol and tobacco are other causes of nervous deafness; and this symptom has been known to come on suddenly during great mental excitement and after severe hæmorrhage. Fatigue of the auditory nerves, as a consequence of long-continued exposure to monotonous sounds, is a not infrequent cause of impairment of hearing: instances of this character are sometimes seen in engine-drivers, smiths, coopers, and boiler-makers. In the case of engine-drivers, good hearing-power is almost as important as perfect vision. It is a mistake to suppose that so long as such men can hear a conversation in ordinary voice there can be no dangerous impairment of hearing. Other sounds besides those of a whistle and a fog-signal often give important warning to a driver. An unusual sound may be the first intimation that some portion of the machinery has broken down or is out of order, and this might pass unnoticed by a man with a slight defect of hearing. So, too, the signal by which the guard can communicate with the driver might remain unheeded. Dr. Hartmann alludes to the fact that an engine-driver, who already hears badly, is liable to hear much worse after having made a long journey, and recovers the loss only after rest.

In these cases of defective hearing due to occupations, both ears are usually affected; and in some a disorder of the middle ear is superadded to that of the labyrinth. As a general rule, however, the symptoms are due to changes in the internal ear. They consist in impairment of hearing, subjective sensations and sometimes in disorder of equilibrium.

Habermann* examined thirty-one chain-workers, and found that all were more or less deaf. In a few cases there was some affection of the middle ear; and in these persons, the hearing-power was proportionately greater; the obstacle to conduction appeared to protect the labyrinth from the effects of loud sounds. Dr. Barr examined 100 chain-workers who had been thus occupied on an average for seventeen and a-half years. He four that fifty-nine could not hear whispers; thirty-three could he them with both ears, and eight with one ear. Loud talking w inaudible to thirteen; ten could hear it only on one side, an seventeen on both sides at about a yard off. In these and simil cases, the impairment increases as time goes on; and in son patients the complaint is observed to grow worse even after the have given up work. In several classes of sufferers various oth circumstances assist in producing and aggravating the complain Among these the most important are: atmospheric change exposure to cold and damp, dust, and particles of various kin which irritate the naso-pharynx. Engine-drivers and stokers ar obviously exposed to the action of all these causes.* Few escap after from five to ten years of service.

---

* *Arch. f. Ohrenheilkunde*, vol. xxx. p. 1.

In all cases of nervous deafness, loss of bone-conduction wi be superadded to the impairment of hearing ordinary sonorou vibrations. The anæsthesia is sometimes partial, in so far as i relates to certain sounds or notes; thus a tune may be hear perfectly, while the patient is decidedly deaf to conversation an common noises. Sometimes an opposite condition is discoverable and very curious differences of this kind are occasionally notice in different patients and in the same patient at different times Thus some hear speech far better than any other sound; whil others who can detect some peculiar sound, such as the tickin of a watch, are comparatively deaf to all others. In connection with these cases, Urbantschitsch suggests that each root of the auditory nerve may possess a different functional importance. This hypothesis would serve to explain the fact that under certain pathological conditions, the hearing-power for articulate speech remains intact, whereas rhythmical sounds are imperfectly heard. Many persons decidedly deaf find that there is a marked improvement when the sound comes from a certain direction; some instances are described in which the patients heard fairly well only when words were uttered immediately behind them.

In one form of nervous deafness certain notes, or perhaps an entire octave, are lost; or it may happen that the want of perception extends to high and low notes at the ends of the scale.

---

* See a Paper on "Railroad Accidents in connection with Bad Hearing of Engine-Drivers," by Dr. Moos, of Heidelberg.—*Archives of Otology*, vol. xi. p. 91.

In elderly persons high notes are often lost, and the same symptom is not infrequent in connection with various labyrinthine disorders. Dr. Wollaston recorded a case in which the deafness involved four octaves; he also alludes to the frequency of deafness for high notes, such as the chirping of a cricket, and states that the loss of perceptive power is sometimes very sharply defined. These cases of deafness for certain sounds are explained by the hypothesis that separate portions of the membrana basilaris are adapted for the perception of certain notes; though the possibility of central lesions must be borne in mind. Similar effects may be produced by obstacles to sound-conduction; for these do not invariably affect all notes, but sometimes different notes in different degrees.

Closely allied to nervous deafness is the condition termed "paracusis loci," in which the faculty of distinguishing the direction whence sounds come is impaired or abolished. The anomaly is associated with deafness on one or both sides, and is due to the fact that sounds are referred to the side on which they are best heard. When the deafness is bilateral it is necessary that the loss should be more marked on one side than on the other.

Subjective Auditory Sensations are those which occur in the absence of any demonstrable objective cause. They are due either to the existence of some pathological process in the sound-conducting apparatus, or to some affection of the auditory nerve or nerve-centres. Deafness is not an invariable accompaniment, but is present in many cases.

Subjective auditory sensations differ greatly in character; and a large number of terms are used by patients in attempting to describe them. Thus they are spoken of as ringing, whistling, singing, whizzing, buzzing, roaring, bubbling, crackling, etc. Patients are apt to compare the sounds with those that are most familiar to them. Sometimes several sounds are heard, either together or consecutively, in the same ear. Their quality is no guide as to their source; the weaker they are the lower is the pitch, and the more they resemble a diffused dull noise. On the other hand, with increased loudness the higher is the pitch, and the sound more and more resembles a musical note. The sensations vary much in strength: sometimes they are very slight, and not noticed when the patient's attention is in any way distracted; in other cases they are so pronounced as to mak the patient utterly miserable and unfit for the duties of lif and even to cause melancholia and suicide. A vast number degrees exist between these extremes; many sufferers get accustomed to the sounds, and are but little incommoded by them.

The character and intensity of the sounds are apt to var from time to time, sometimes without apparent cause, sometime as a result of changes in the condition of the ear, or in externa circumstances. Thus the noises are generally more troublesom when any existing catarrh of the tympanum or throat become exaggerated, in damp weather, after exposure to cold, after sleepless night, and as a result of indigestion. In some patient they are worse in the morning; in others, after the fatigues the day.

There is a remarkable peculiarity connected with subjecti auditory sensations, viz., that sometimes they appear to originat external to the ear and at various distances from it; in othe cases, their source appears to be situated within the cranium In the latter case the sound may appear to proceed from ever part of the head, or only from certain spots; in another class sufferers there is a continuous noise within the cranium, wit the occasional or frequent addition of louder sounds, resemblin explosions. It must be remembered that when the auditor nerve is physiologically excited, the resulting sensation of soun is referred to some external object. The same idea is forme when the excitement is due to some pathological cause; but th patient after a time discovers the mistake, and becomes consciou that the sound really originates in the ear or in some other par of the head. Even when this stage has been reached, the patien may from time to time refer the sound to some external cause.

The sound may be heard by one or both ears; in the latte case the source of the sensation appears to be in the head, eithe in the middle, fore, or back part of it, provided that both ear are equally affected. If the sensation be more acute on one sid than on the other, the sound will seem to originate nearest the ear which is most affected. When, as sometimes happen the intensity of the sound varies from time to time, the idea to its source of origin will likewise change. Very feeble sound usually seem to originate within the ear.

Causes.—For the production of subjective auditory sensation some pathological condition of the sound-conducting or sound-perceiving apparatus must necessarily exist. With regard to the former, subjective sensations are one of the most prominent symptoms of adhesive inflammation of the middle ear, the drawing inwards of the base of the stapes being the immediate cause. The same result ensues when the membrana tympani and the chain of ossicles are forced inwards, when the air in the middle ear is rarefied, and when there is increased action of the tensor tympani muscle, or retraction of the tendon of the stapedius.

Politzer* states that constant and vehement tinnitus is a marked characteristic of primary disease of the bony labyrinthine capsule, the result of such disease being neoplastic osseous tissue, which gradually pushes aside the normal bone, and, when attacking the fenestra ovalis and stapes, closes the former *in toto*, and produces anchylosis of the latter. Most of such patients are totally deaf. On post-mortem examination, the niche of the fenestra ovalis is beset with more or less sharp bony protuberances, marked off from the neighbouring district by a curiously reddish tint. The stapes is almost always immovable; its base is thickened and its crura roughened; sometimes the entire ossicle is transformed into a solid mass.

Other pathological changes in the cochlea and in the auditory nerve-centres are capable of giving rise to subjective sensations of hearing. Thus the latter often occur in cases of anæmia and chlorosis, after severe losses of blood, and in the opposite conditions of hyperæmia and cerebral congestion. Inflammation of the brain and cerebral tumours are often accompanied by marked subjective auditory sensations. Not infrequently they constitute the warning symptoms of epileptic attacks; in these cases, the auditory centres in the cortex of the brain must be regarded as their source. Full doses of certain drugs—*e.g.*, quinine and salicine—are apt to affect the hearing and to excite subjective noises, as of bells ringing in the ears. The sense of hearing is sometimes decidedly impaired for several hours or days; but the effects usually pass off soon after the medicine has been discontinued. Galvanism applied so as to excite the auditory nerve always causes a sensation of sound. In some cases the noises are heard only in certain positions of the head: they are often more distinct when the patient is lying down.

---

* *Archives of Otology*, 1894, p. 255.

the sensations; but other influences may co-operate in the production of the result. It is a well-ascertained fact that in some cases the noises may be made to cease by listening to external sounds; but this experience is not universal. On the other hand, in some instances the subjective sounds are intensified in the presence of other noises, and this result may be explained by supposing that fatigue of the nerve-centres has resulted from their excitement. Another variation is occasionally noticed, viz., the production of a subjective auditory sensation by an external sound. Some patients are free from any trouble of the kind so long as silence reigns around them; but the least noise provokes the peculiar sensations, which then continue indefinitely. The echo-like additions to certain sounds constitute kindred phenomena. In some cases every syllable seems to be repeated in a lower note, although of the same duration. In others, a peculiar clanging character is added to all sounds.

In some patients the sounds are only occasionally noticed; in others they are always present, though liable to variations in intensity. In the former class the sounds may trouble the patient either at definite or indefinite intervals, and sometimes the periodicity is maintained during months or years. The noises are sometimes associated with discharges from the ear and other symptoms of otitis, which likewise assumes an intermittent character. In another class of cases the auditory sensations are associated with severe coryza, of an intermittent character, and for which the inhalation of two or three drops of amyl nitrite proves a very efficient remedy.

The continuous subjective auditory sensations may be developed either gradually or suddenly; in some patients the noises are at first irregularly intermittent, and afterwards become continuous. Even when this latter stage has been reached, exacerbations are wont to occur, and the intensity of the sounds is generally influenced by such conditions as the general health of the patient, the state of the weather, etc. The noises are always more troublesome if the patient becomes weak and depressed from any cause; in some patients the noises are made worse by a little alcohol; in others an opposite result is experienced. External noises are sometimes sufficient to mask the subjective sensations, which then become noticeable only at night.

Aural tinnitus is often accompanied by vertigo; but the relation between the two phenomena varies greatly. Sometimes a gradual increase of the subjective sensations precedes the vertigo; in other cases the former are experienced, but only in a moderate degree, before the giddiness is noticed, and the two sensations pass off at about the same time. Nausea and vomiting are sometimes superadded; and, if there be any degree of deafness, the symptoms closely resemble those of Ménière's disease.

It is necessary to distinguish between subjective sensations proper and the so-called "entotic" noises, which originate in the middle ear or adjacent parts, and are transmitted to the labyrinth. These noises are often caused by the condition of the blood-vessels, and anomalies in the circulation in the small arteries supplying the ear. In some cases murmurs originating in the internal jugular vein are transmitted in an upward direction, and become clearly audible: the sound ceases, however, when pressure is made upon the vein in the upper part of the neck. It has been suggested that an enlarged jugular fossa may be the source of origin of an entotic murmur; the opening of the sigmoid sinus into the fossa is often very narrow, and increased rapidity of the blood-current may cause a bellows-sound. Hyperæmia of the tympanic vessels, and especially of those of the malleus, may cause vibration of the ossicles, and consequent sensations of sound; noises due to this cause ought, however, to cease when the jaws are firmly closed, inasmuch as the tympanic artery is thereby compressed as it enters the Glaserian fissure. Valvular diseases of the heart not infrequently give rise to entotic sounds. The latter sometimes originate in close proximity to the labyrinth; thus they may arise from contraction of the muscles, either the tensor tympani or stapedius, from collections of secretion in the tympanum, and from movements of the membrane or of the walls of the Eustachian tubes. The perception of these noises is favoured by increased sensitiveness of the auditory nerve, and by anything which increases the resonance within the ear, such as closure of the meatus. Sometimes these entotic noises are so loud that they can be distinctly heard by others, and they are then termed "objectively perceivable." Among such sounds may be mentioned a cracking noise in the maxillary articulation, produced by traction of the muscles on the Eustachian tube.

Subjective auditory sensations are often very important symptoms; they are liable to exercise a marked influence on the health and spirits of the patient, and are often associated with other symptoms of aural disease. More or less deafness is the usual accompaniment, and its development sometimes precedes and sometimes follows that of the tinnitus. There is, however, no necessary correspondence between the intensities of the two symptoms; severe deafness may be associated with slight tinnitus, and indeed may exist without any trace of the latter. Moreover, in some cases in which the two are associated, the deafness eventually becomes complete, while the tinnitus altogether ceases, and this result may be attributed to decided anæsthesia of the auditory nerve. If, in such a case, the hearing be improved by treatment, the tinnitus may return, and the trouble it causes may outweigh the relief in the other direction.

It is not always possible to decide whether the sounds are subjective or entotic. If they are audible to a bystander there is, of course, no doubt as to their origin. In like manner, if the sounds can be made to cease by compressing the carotid artery or jugular vein, they belong to the category of entotic noises. Sounds which are due to disorders of the tympanum are apt to vary in intensity and quality from time to time, the changes depending upon improvements or exacerbations of the aural disease. Sounds depending on the presence of foreign bodies—*e.g.*, plugs of cerumen—generally subside after removal of the latter, unless various changes have been set up, which require some time for their disappearance. Subjective sensations, coming on suddenly, and of a decided character, depend for the most part upon some affection of the labyrinth, and especially of the cochlea, or upon some central lesion; they may, however, be due to sudden effusion into the tympanum. When the subjective sensations occur in persons presenting signs of nervous or mental disorder, they are presumably referable to some central affection of the auditory nerve.

It must be remembered that in some cases the noises are due to movements which the persons have acquired the habit of making, and which in the course of time occur almost involuntarily. Thus some children amuse themselves by producing noises in the throat by rapidly contracting the muscles of the soft palate. Adults have been known to fall into the same habit from practising movements for the relief of disagreeable sensations in the upper part of the pharynx; and when this habit has b acquired, the muscles are apt to contract spontaneously. The d gnosis is not difficult, inasmuch as the contractions and accompa ing noises cease when the patient makes an effort for that purp

In some cases the patients state that the sounds they hear those of human voices or of the cries of animals, and someti words or sentences are declared to be distinctly perceived. S a symptom is not uncommon in insane patients, but it also occ in persons in good mental condition. Prof. Huxley relates t "in reading books written by persons with whom I am acquaint I am sometimes tormented by hearing words pronounced in exact way in which these persons would utter them, any trick peculiarity of voice or gesture being also very accurately rep duced." He goes on to say that he supposes "that every must have been startled, at times, by the extreme distinctn with which his thoughts have embodied themselves in appar voices." In some of these and similar cases there is a delus of the senses; in others, a delusion of the judgment. Th mistakes are sometimes made by deaf persons, who are free fr tinnitus, but misinterpret various sounds. Decided audit hallucinations are sometimes associated with various pathologi conditions of the auditory apparatus, and subside when these removed. Thus a plug of wax in the ear may be the real ca of subjective sensations, in which cries resembling those o human being are heard, and which cease at once on the remo of the foreign body. That hallucinations, however, may dep upon irritation of the cortical centres is proved by the fact t they are sometimes present in persons who are totally deaf all ordinary sounds.

In still rarer cases than those hitherto mentioned, the s jective sensations are those of tunes or melodies, and these m be classed among hallucinations. Hartmann mentions the c of a musically trained lady, under his care for nervous duln of hearing in a very advanced stage, and who heard for a lo time the most exquisite melodies, mostly well known to h After a time they were confused together, so that utter disc was created.*

---

* Many interesting details with regard to aural tinnitus may be found Dr. Gowers' Bradshaw Lecture on "Subjective Sensations of Sound." *Bri Medical Journal*, 1896. vol. ii. p. 1,429.

Prognosis.—The prognosis in cases of subjective auditory sensations depends upon the cause and upon the condition of the patient and the auditory apparatus. If there be chronic adhesive catarrh, in all probability the sounds will not be influenced by any form of treatment. On the other hand, if the case be one of anæmia or neurasthenia, much good may often be effected by appropriate measures. Continuous noises, and sounds of a definite character, are more likely to be permanent than intermittent and indefinite sounds. When, with obvious disease of the tympanum, sounds previously intermittent become continuous, there is reason to believe that the aural complaint has increased in severity. As a general rule, the prognosis is unfavourable in proportion to the intensity of the sensations, and the time during which they have continued.

Treatment.—Our first effort should be to discover and to remove the cause; the patient should be carefully examined in order to detect any existing affection of the ear, nose, or throat, any disorder of the nervous system, or any constitutional disease. Inquiries should be made into his habits of life, diet, use of alcohol and tobacco, quantity of sleep, and other circumstances calculated to affect the nervous system. After attending to all these subjects, various special means may be tried. Relief is often afforded by inflating the middle ear through the catheter, and thus reducing the intra-labyrinthine pressure. Equally good results are sometimes obtained by rarefying the air in the meatus with the aid of Siegle's speculum or Delstanche's *rarefacteur.* The effects, though often marked, usually subside more or less rapidly.

Some authorities, notably Politzer and Gruber, recommend the introduction of the vapour of chloroform or of ether into the tympanum through the catheter. Solutions of these drugs may also be tried—*e.g.*, a few drops of such mixtures as ether, two to four parts; glycerine, eight to twelve parts; or chloroform and glycerine in similar proportions. The hydrochlorate of cocaine is another remedy of this character; five to ten drops of a 6 per cent. solution may be injected at intervals of three or four days. Amyl nitrite proves very useful in some cases; the patient should inhale the vapour of two or three drops, poured into a cone of blotting-paper.

Local applications to the meatus and neighbourhood of the ear are sometimes tried, but seldom prove efficacious. Morphine, iodide of potassium, cocaine, and camphor are thus used, either in the form of ointment or in solution. The local application of sulphuric ether sometimes does good; it should be mixed with olive oil (5 to 15—25), and either instilled into the meatus or introduced on a pledget of cotton-wool. It causes a pleasant sensation in the ear, and often lessens the tinnitus. If the sensations are very troublesome at night and prevent sleep, the subcutaneous injection of morphine is likely to prove useful.

Remedies administered internally often do more good than external applications of any kind. The bromide of potassium is one of the best remedies for subjective auditory sensations occurring in nervous, restless persons; it should be given in full doses of from fifteen to thirty grains, and in some cases a combination of chloral with the bromide acts very satisfactorily, and much better than either drug alone. Hydrobromic acid will relieve noises of a pulsating character; and in a similar class of cases, and for nervous subjects, camphor is often useful. The tincture may be given internally in ordinary doses. For pulsating sounds, connected with or independent of heart disease, Politzer recommends the tinctures of digitalis and of strophanthus, and states that he has often witnessed good results from both these remedies.

Various tonic and antispasmodic remedies will, in some cases, relieve or even cure subjective auditory sensations. Strychnine is likely to be useful whenever there are symptoms of nervous debility; it may be used subcutaneously or internally. Iron is, of course, indicated for weakly and anæmic subjects; any of the usual preparations may be given, proper attention being at the same time paid to the state of the bowels. Quinine, if specially indicated by any complication, must be given with great care; it often aggravates aural sensations. When used it should be combined with hydrobromic acid. Valerian is recommended by some writers; Gruber has obtained very good results from arnica in nervous cases; he gives the tincture, in doses of from five to fifteen drops, several times daily.

In tuberculous and syphilitic subjects various combinations of iodine are likely to be serviceable; weakly patients are to be treated by long courses of the syrup of the iodide of iron, and when there is any history or suspicion of syphilis, the iodide of potassium should be given in full doses, and continued for several weeks. Iodine ointment may at the same time be applied to the mastoid process, and warm baths will aid the other remedies. Arsenic has been known to relieve subjective auditory sensations, and the late Mr. Hinton strongly recommended the chloride of ammonium, in doses of twenty grains, three times a day.

When there are signs of cerebral congestion, purgatives are indicated, and salines are most likely to be useful. In the same class of cases it is sometimes advisable to apply leeches from time to time to the mastoid process, or to take a few ounces of blood by cupping at the back of the neck. Blisters (see page 349) are likely to be advantageous when the symptoms are chronic and of a milder character. Great care should be paid to the diet, mode of living, etc. Rest and change of air often do good, and materially assist the action of the various remedies already mentioned.

Electricity is sometimes useful in cases of tinnitus aurium; the manner of application will be described in a succeeding chapter. Only very mild continuous currents should be employed, and the sittings should occupy from ten to twenty minutes on alternate days.

CHAPTER XLV

ELECTRICITY IN THE TREATMENT
THE EAR.

Physiological Action of Galvanism upon the
Produced—Other Effects, as Pain, Gidd
periments — Duchenne's Method — Ben
Electricity in the Treatment of Aura
Method—Instruments used by Author.

THE galvanic current is useful in some f
ear; the faradic current is serviceable in
of cases. The physiological action of gal
tory nerve has been carefully studied by
our present knowledge of this subject i
observers. The results of their investigati
summarised:—When the negative pole is
and the positive to any other part of
opposite side of the neck or the back o
sound is heard when the circuit is clos
some time, and finally ceases. When
whether by removing the electrode or by
continuity, no sound is heard. When the
on the tragus, and the negative on the
sound is perceived when the circuit is cl
the same while the electrodes remain in po
the circuit a faint sound is heard. Th
consist of humming or buzzing sounds
slight force; but when the latter is incre
heard. Some authorities state that the
is not influenced by the strength of the

sound produced always corresponds with the resonance-note of the sound-conducting apparatus.

According to Brenner, the sound, whatever may be its character, is caused by the galvanic stimulus applied to the auditory nerve, and is not due to reflex action through the trigeminus. In opposition to this view is the fact that when the cutaneous sensibility is diminished, a stronger galvanic current is required to produce the auditory sensations; on the other hand, when there is cutaneous hyperæsthesia, the auditory nerve reacts more powerfully. It has been supposed that the sensation might be caused by contraction of the internal muscles of the ear, but Urbantschitsch found that after tenotomy of the stapedius muscle, the stapes being quite isolated, sounds were still produced when galvanism was applied.

In order to test the condition of the auditory nerve, the negative pole is placed on the tragus, and the positive on the back of the hand; a weak current is then used, say of three elements, and if there be no reaction when the circuit is closed, the number is increased till a sound is heard; the number used expresses the condition of the nerve. It sometimes happens that a sound is heard in the opposite ear; the latter is under the influence of the other electrode.

Other sensations besides those of sound are not infrequently produced by galvanism applied to the ear. In some cases there is severe pain, especially when a pointed electrode is used, and on this account a somewhat broad instrument should be chosen. The positive pole causes a dull, heavy pain, or feeling of weight in the ear; the negative gives rise to a sharp, pricking sensation, which assumes a burning character in a short time. Another effect is contraction of some of the facial muscles, and especially of the orbicularis palpebrarum, zygomatici, corrugator supercilii, occipitalis, and sometimes of the ear-muscles, and of those of the lower jaw. These symptoms are most distinct when the negative pole is applied to the ear and the circuit closed. In some patients, flashes of light appear before the eyes; in others, giddiness becomes very troublesome. This latter symptom is most marked when the electrodes are applied to the sides of the head, at points opposite to each other; but is less severe when the electrodes are so arranged that the current is parallel to the long axis of the body. The giddiness is often accompanied by

vomiting and nausea, and may last f
symptoms less frequently noticed are–
when the circuit is opened and closed;
gustatory sensations; and tingling or it
the tongue.

Brenner's experiments on aural pa
condition of the external and middle ear
galvanic reaction. When the external
ism applied to the tragus produces littl
perforation of the membrane exists, th
marked. In cases in which the reacti
produced with difficulty, the cause is o
some obstacle to conduction, and not i
of the auditory nerve itself; the latte
circumstances more often in a state
Simple hyperæsthesia is evinced by th
the sensation and the ease with whi
marked cases it is sufficient to apply
little distance from the tragus. Dimini
is shown by the rapid passing away of
as by the difficulty in producing them.
may exist in association with absolut
bone-conduction.

The induced current is sometimes u
deafness, and Duchenne's method is pr
employing it. The patient's head is so
auditory meatus is perpendicular. A lit
into the canal so as to fill about half of
then introduced, care being taken not to
meatus or the membrana tympani. It
rheophore, in which the wire is isolated b
is prevented from touching the membra
the buzzing caused by the pressure of
the ear-rheophore is connected with one
induction apparatus, and the circuit is c
moist rheophore on the mastoid process,
the second conductor. The current, thu
sensation of a dry sound; a tickling in
bottom of the ear; a peculiar taste, and
the side stimulated. The flow of saliva i

but this change is always preceded by a feeling of dryness on the side of the tongue affected.

With regard to the effects of the induced current, Duchenne states that it causes contraction of the small muscles, movements of the chain of bones, vibration of the membrane of the fenestra ovalis, and consequent agitation of the fluid of the labyrinth. He obtained good results in cases of "hysterical" deafness, in deafness from quinine, and in deafness following continued fevers. In very sensitive persons, and especially when the tissues of the meatus and membrane are much injected, it is best not to pass an electrode into the canal, but to place it on the mastoid process, while the other one is applied over the malar bone, or in front of the ear.

According to Benedikt, sounds are much more readily produced by the electric current in diseased ears than when all the structures are normal. He also believes that acoustic sensations can be produced through the sympathetic nerve by reflex action, and he applies the current to the latter for therapeutical purposes. Schulz explains the action of the galvanic current in a different manner; he supposes that the peripheral twigs of the sensory nerves at the spot where the electrode is applied are rendered electrotonic. This condition is propagated to the central extremities of the nerves, and thence to the sensorium, which becomes conscious of the change in the electro-motor condition.

There is considerable difference of opinion as to the value of electricity in the treatment of diseases of the ear, and no definite rules can be laid down for its employment. It is sometimes useful as an adjunct to other remedies. Thus, galvanism applied to the tragus may restore bone-conduction, increase hearing-power, and relieve subjective sensations. It must, however, be confessed that the result is sometimes negative, and sometimes even prejudicial, inasmuch as the symptoms are aggravated by the treatment.

The method of applying electricity to the ear, proposed by Weber-Liel, yields good results in certain cases. He introduces the current through the Eustachian tube by means of a silver wire passed through a catheter. The galvanism thus acts upon the muscular structures of the tube, and possibly upon the tensor tympani and stapedius. No effect is produced upon the auditory nerve; but this method of application sometimes causes subjective sensations to cease, and improves the hearing. The remedy is, of course, applied to the middle ear. and it may be useful in cases of atrophy or degeneration of the muscular structures. Weber-Liel states that after the tubal muscles have been thus galvanised, air passes more readily through the catheter into the tympanum, and that Valsalva's method succeeds where before it failed. As, however, improvement of a similar character is not infrequently obtained by means of the catheter alone. this instrument should be used before electricity is resorted to. or both methods of treatment may be employed. From the therapeutic point of view it is immaterial to which cause an improvement is to be attributed.

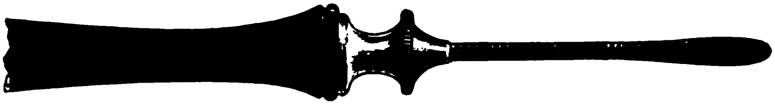


FIG. 127.

THE AUTHOR'S AURAL ELECTRODE.

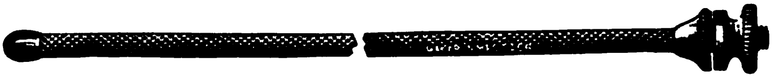


FIG. 128.

THE AUTHOR'S PHARYNGEAL ELECTRODE.

The instruments generally used by the author are shown at Fig. 127 and Fig. 128. The former is moistened in salt and water and then inserted into the meatus; and the latter is placed against the soft palate and then lifted upwards and outwards, so that its extremity may be near the pharyngeal termination of the Eustachian tube. This method is less troublesome and is less disagreeable to the patient than most of the plans mentioned, and is, moreover, equally efficacious. By this means the author has obtained results similar to those mentioned by Weber-Liel.

CHAPTER XLVII.

DEAF-MUTISM.

Classification of Deaf-Mutes—Statistics—Deaf and Dumb in Great Britain and other Countries—Influence of Sex—Causes of Congenital Deaf-Mutism—Hereditary Transmission and Consanguineous Marriages—Pathological Appearances—Acquired Deaf-Mutism—Age of the Sufferers—Additional Symptoms and Consequences—Diagnosis—Prognosis and Treatment—Importance of Early Instruction—Urbantschitsch's Method.

CHILDREN learn to speak by hearing words pronounced by others and endeavouring to reproduce the sounds. A child destitute of the sense of hearing remains dumb, and those children who lose their hearing-power during infancy or before they have thoroughly learnt to speak, lose the faculty they may have acquired. There are, therefore, three classes of deaf-mutes:—

1. Those who are congenitally deaf.
2. Those who have become deaf after birth and before acquiring speech.
3. Those who have become deaf after having acquired the faculty of speech to a greater or less extent.

Statistics carefully collected by Dr. A. Hartmann,* of Berlin, show that, taking countries with an aggregate population of 246,000,000, there is an average proportion of 7·77 deaf-mutes in every 10,000 individuals. The proportion is lowest in the Netherlands, being 3·35; and highest in Switzerland, viz., 24·5 in every 10,000 inhabitants. In Great Britain the proportion is 5·57.† The statistics prove that deaf-mutism is far more common in mountainous districts than in level countries, and that in Europe it is remarkably frequent in the Alps and Pyrenees.

---

* *Taubstummheit und Taubstummenbildung.* Stuttgart, 1880.

† *Report of the Royal Commission on the Blind, Deaf, and Dumb.*

eleven deaf and dumb children. Mr. Bell states that with one parent who is a congenitally deaf-mute, one-tenth of the children are deaf; and with both parents congenitally deaf-mutes, about one-third are born deaf.

Consanguineous marriages play an important part in respect to deaf-mutism; but the statistics are not kept with sufficient accuracy to admit of more than general conclusions. The frequency of the defect in Alpine districts is traceable, in a measure, to the marriages of relations; and, according to good authorities in New York and elsewhere, one out of every ten congenitally deaf-mutes is the offspring of consanguineous parents. There is abundant proof that a marriage of this character occurring in a family in which there is already deafness, results in a marked tendency to the defect in the offspring; the family peculiarities, whatever they may be, are thus reinforced. Dr. Hartmann records a very remarkable example of the influence of consanguineous marriages. "'A deaf-mute child had other five deaf-mute brothers and sisters; and, although no case of deaf-mutism had occurred in former generations of the family, it was found that the parents, as well as the grand-parents and great-grand-parents, had been cousins. Thus the pernicious effect of consanguinity did not show itself until after the third marriage." The same author states that in Prussia, where the number of consanguineous marriages yields a percentage of 0·8, there were among 1,210 congenital deaf-mutes 156, or 12·9 per cent., who were the offspring of these marriages; while among 1,551 individuals with acquired deafness, there were only 47, or 3 per cent., who sprang from such marriages.

Pathological Appearances.—Various pathological changes have been found in cases of congenital deafness, the most prominent being evidences of intra-uterine meningitis and of inflammatory processes in the middle ear and labyrinth; arrested development of parts of the ear and of the auditory nerve and centres; bilateral atresia of the external meatus and tympanum, and rachitic processes in the labyrinth. Syphilis and tuberculosis would appear to account for a small proportion of cases of congenital deafness. In two cases described by Moos,* there was a remarkable flattening of the occipital region and considerable atrophy of the posterior cerebral lobes. In one of these, a boy aged four.

---

* *Archives of Otology*, vol. xi. p. 307.

there was also distinct paresis of the right arm and leg, and marked congenital talipes on both sides.

The petrous bones from six deaf-mutes have been examined by Drs. Moos and Steinbrügge.* In two cases no nerves were discoverable in the lamina spiralis ossea in the first turns of the cochlea; the ganglion cells within Rosenthal's canals were stunted or atrophied; the organs of Corti were imperfectly developed and in a state of fatty degeneration; the ductus cochlearis and scala vestibuli were filled up with caseous masses. In one case the labyrinth was altogether absent on both sides, and the auditory nerves were for the most part atrophied. In another case there were connective-tissue adhesions in the scala tympani, defects in Corti's organ, and of the nerves and ganglion cells in the first and second turns of the cochlea. The osseous parts of the ear presented various changes, some of a hyperplastic, others of a destructive character.

Acquired Deaf-Mutism is caused by various changes in the organ of hearing, which in their turn result from affections of the central nervous system, of the labyrinth, and the sound-conducting apparatus. Cerebro-spinal meningitis, inflammation of the labyrinth, scarlatina, diphtheria, typhoid fever, measles, acute hydrocephalus, syphilis, and mumps, are the diseases to which the majority of cases belonging to this class are traceable. The lesions found in the ear are: the remains of suppurative inflammation in the tympanum; exfoliation of the ossicles; caries and necrosis of the labyrinth; bands of connective tissue preventing movements of the ossicular chain; adhesions of the ossicles to the walls of the cavity; destructive changes and osseous formations in the labyrinth; inflammatory deposits in the meninges involving the auditory nerves on both sides, and in the floor of the fourth ventricle. Adenoid growths in the naso-pharynx are very common in deaf-mute children. They are said to occur in 60 per cent. of all cases.

The **Age** of the patients at the time of becoming deaf is a point of much importance. When a child becomes deaf during the first four years of its life, it very seldom acquires the faculty of articulate speech. When the deafness comes on between four and seven years, much will depend upon the intelligence of the child and the care taken by its parents or guardians. After seven years the power of speaking is generally preserved; but cases are on record in which it was lost by children who became deaf after attaining fourteen years of age. Wilde's statistics of 503 cases show that 120 became deaf in the first two years; 109 in the third and fourth; 76 in the fourth; 38 in the fifth; 36, 32, and 21 in the sixth, seventh, and eighth years respectively; 11 and 15 in the ninth and tenth; 33 between the tenth and fifteenth, and 12 after the latter year.

---

* *Archives of Otology*, vol. xi. pp. 236, 299; vol. xii. p. 304; vol. xiii. p. 247; vol. xv. p. 123.

In these cases of congenital and acquired deaf-mutism, the dumbness is, of course, the result of the defective hearing. The influence of hearing upon speech is shown by the alterations in the voice among deaf persons in general: it becomes harsh, loud, and inflexible. These features are especially marked in deaf-mutes. When the deafness has been acquired in early childhood, there is no longer any great inducement to speak, and with loss of practice the power disappears, the voice becomes harsher and less intelligible, and, in the absence of proper care and attention, dumbness is superadded to the loss of hearing. The want of exercise of the lungs and throat is found to result in imperfect development of the thoracic muscles and flattening of the chest. Hence the deaf and dumb are predisposed to lung-disease and to chilblains. In other respects, however, the sufferers are well developed, and many of them exhibit a high degree of mental power. As a general rule, they are capricious, obstinate, ill-disposed towards other children, and shy, though inquisitive; capacity for imitation is often a marked feature.

Diagnosis.—In early life it may be difficult to ascertain whether and to what extent the child is deaf. Absolute deafness is less frequent than loss of perception of speech. A mother should consult an aurist for her child whenever she observes that it is unaffected by sounds and speech. A child may be able to repeat such words as "papa" and "mamma," and yet be very deaf; for these and other words of a few syllables are acquired by merely watching the movements of the lips. Such words would not be repeated if the child could not see the mouth of the speaker. The eye takes the place of the ear, and enables the oral and facial movements to be reproduced.

In order to test the condition of the hearing, the child's attention should be excited, by toys or other means, while sounds of various intensities are produced (by clapping the hands, ringing a bell, or whistling) behind his back. Perception will be demonstrated by the child's turning his head towards the source of the sound. It must be remembered that loud noises are always accompanied by more or less vibration of the walls and floor of the room, which can be *felt* by a person whose attention is thus attracted, although totally deaf. A child quite deaf to ordinary tests may *seem* to hear the slamming of a door or the falling of a weight on the ground. Such noises are not tests of hearing-power. The perception of sound through the bones of the head is tested in the ordinary way by placing tuning-forks of varying pitch on the vertex or mastoid process. A child more than twelve months old will smile if he hears the sound. Low notes are usually heard better than high ones. If sound be perceived, a further examination will determine whether speech of any kind is heard. Some deaf-mutes hear to such an extent that they are able to repeat vowel-sounds, especially *a*, *o*, and *u*, uttered close to the ear. Others are able to repeat consonants, and even a few words. Dr. Hartmann's statistics show that 60·2 per cent. of the total number of deaf-mutes are entirely devoid of the sense of hearing; a fourth part are able to perceive sounds; 11·3 hear vowels, and 4·3 hear words. "The chief point of distinction with regard to the hearing-power of those born deaf and those who have acquired deafness, is that of the latter the number of the totally deaf is far larger (68·4 per cent.) than that of the former (42·2 per cent.)."

Prognosis and Treatment.—In a few congenital cases, the deafness not being absolute and due to changes in the middle ear, some improvement has been observed to take place in the course of time. Dr. Hartmann mentions the case of a girl, totally deaf since birth, in whom hearing was established spontaneously to such an extent that she was able to repeat words spoken close to the ear. Politzer also records a few similar cases. Practically, however, any child unable to hear ordinary voice at a distance of two or three feet from the ear is unable to acquire language by the ordinary method. In acquired deaf-mutism, resulting from destructive processes in the middle ear, or from disease of the brain or its membranes, no improvement can be expected. Attention should, however, be paid to the condition of the ears and of the naso-pharynx; and suitable treatment should be adopted for any purulent discharge, or chronic inflammatory processes. When the case is one of a child who has learnt in some measure to speak, every effort should be made to prevent loss of the faculty already possessed. To this end the child should be encouraged to speak, and made to read aloud regularly and distinctly. Too much stress cannot be laid on the importance of proper treatment of aural disease in early life. In not a few cases of deaf-mutism, the deafness and its result are due to neglect.

At the present day there are three systems whereby deaf-mutes are educated: these are (1) the sign and manual, (2) the pure oral, and (3) these two combined. The object of each is to enable the sufferers to converse with their fellow-creatures, to acquire knowledge, and to earn their own livelihood.

The differences between the three systems are thus tersely stated in the Commissioners' Report:—The sign and manual system specially trains the deaf to communicate and associate with their fellow deaf.

The pure oral system specially trains the deaf to communicate and associate with the hearing and speaking world.

The combined system, as its name implies, endeavours to combine the two former, the result being that, with few exceptions, signs and the manual alphabet prevail, and cause the pupils to relinquish the use of speech, and to seek the society of deaf and dumb people.

The arguments which the advocates of the different systems advance to establish their case may be summed up in a few words. Starting with the assumption that a written language is common to all, the advocates of the first system claim that the sign language is the natural way in which the deaf and dumb express themselves. Those who maintain the superiority of the oral system allege that their aim is to make the deaf and dumb conversant with ordinary language and able to express themselves by speech. The advocates of the third plan assert that it is best to give the deaf and dumb the advantages of both systems.*

It would seem that the sign and manual system has nearly

* *Report of the Royal Commission*, p. 62.

died out in the United Kingdom. The Commissioners recommend that every child who is deaf should have full opportunit of being educated on the pure oral system. The first step i this system is to teach the deaf-mute to learn what anoth person is saying to him by noticing the movement of the lip This necessitates very careful articulation by the teacher, an very close observation by the deaf-mute, the perfection and spe with which it is learnt varying with the skill and intelligen of the teacher and pupil. The next step, to teach the dumb t articulate, involves more difficulty. The teacher writes a letter o a board, and then pronounces it. The pupil imitates the motio of the lips, and emits a sound which by practice comes t resemble that uttered by the teacher. Various combinations c letters are next taken, and the same process is adopted unti words are learnt. When the pronunciation cannot be learn from the movement of the lips, the teacher places the pupil' hand on his larynx while he utters the sound. These lesson require constant practice, under trained teachers, for six or eigh years, in which period a large proportion of the children becom enabled to make themselves well understood by this system o speech and to carry on long conversations. The result, in th main, depends on their intellectual capacity, upon the amount o hearing-power which may yet remain, and the manner and duration of the training. Dr. Hartmann states that about one-thir can be trained with such success that they can converse wit everybody. In a similar proportion, the speech is somewha less distinct, so that it is not clearly understood by those unaccustomed to it. In the remaining third, the utterances are almos unintelligible.

Children should come under instruction as early as possible before the vocal organs have lost power from disuse, and whil still supple enough to produce sounds free from that harshnes which usually characterises their later development. Even i the results of the oral system prove very imperfect in any given case, yet a little power of speech enables the pupil to communicate with the rest of the world on terms more nearly equal than those afforded by the language of signs or the finger alphabet.

During the last few years, Prof. Urbantschitsch,* of Vienna, has advocated the employment of a system of "Acoustic Gymnastics" or vocal training of the auditory nerve for deaf-mutes. His results have been of a most gratifying character. He has demonstrated the possibility of developing not only perception, but differentiation of sound in children hopelessly deaf and apparently without any perception of sound.

---

* *Archives of Otology*, 1895, p. 50.

The manner of conducting this new system is as follows:—A case of complete deafness or deaf-mutism is presented. In a loud voice, close to the patient's ear, a vowel is sounded; the patient either receives no impression or indicates a very indefinite sound-perception, which may be the same for all vowels: thus *a-e-i-o-u* would all be heard as *a* or *e*, as the case may be. The exercise is begun by indicating to the patient the vowels to be used, as, for example, *a*, as in father, *e*, as in eel. By several minutes' use of these two vowels, pronounced close to the ear in a loud, steady voice, the patient often arrives at a differentiation of sound; perhaps not complete, yet the sounding of *a* produces a different impression from *e*. In some cases, several minutes suffice to acquire such a primary differentiation; in others, a number of sittings are required. By degrees, as rapidly as each individual case indicates, the other vowels should be brought into use. The plainest, simplest sounds of the vowels should be used: *a*, as in father; *a*, as in late; *e*, as in eel; *o*, as in hope; *u*, as in flute. Following the vowels, the consonants should be combined in monosyllables, as *lo*, *may*, *do*, *ba*, *he*. Consonants heard with difficulty and easily confused, as *b* and *p*, *t* and *d*, *g* and *k*, &c., should receive extra attention and be diligently practised. It is well to use monosyllables instead of mere sounds.

Should the patient persist in repeating a wrongly heard word or sound, it is suggested to give him first the right and then the wrong sound, until the differentiation becomes apparent to him. As improvement goes on, whole sentences should follow the use of vowels, consonants, and words. Also the hearing-distance should be gradually increased.

As the patient becomes accustomed to the practice, the speaker's lip-movements should be concealed, so that the results may be those of the aural gymnastics exclusively. Urbantschitsch met with one case in a boy who at first could not hear a single vowel at closest range; in six months he could hear and repeat accurately whole sentences, with the speaker at a distance of five feet and without lip-reading. Other similar cases were noticed.

At the commencement of the treatment, the sittings sho be short, from ten to fifteen minutes, twice or three times da gradually increased to an hour as a maximum. The pitch u and the intensity of the voice must be modified according the case. An ear-trumpet may sometimes be used with adv tage, but caution is required, as the instrument may cause alteration in the timbre.

The use of the system is beneficial in congenital as wel in acquired deafness, and age is no obstacle to success. number of congenitally deaf pupils, who had been thus trea were presented at a meeting of the Society of Physicians, Vien it was shown that they could hear the speaker at distances va ing from several inches to ten feet, and without lip-reading signs.

CHAPTER XLVIII.

ARTIFICIAL AIDS TO HEARING.

Ear-Trumpets and Tubes—Maloney's Otophone—Politzer's Instruments—Rhodes' Audiphone—Paladino's "Fonifero"—Desirability of Early Use of Ear-Trumpet.

In many cases of impaired hearing, conversation is facilitated by the use of ear-trumpets and tubes, which collect vibrations and convey them to the auditory canal. Instruments of this kind are found to be most serviceable when the deafness is due to the results of chronic catarrhal processes in the middle ear, the membrana tympani and ossicles remaining in position. When the deafness is due to disease of the labyrinth, little if any benefit can be experienced from the use of such appliances.

An ordinary ear-trumpet consists of a conical tube with a wide mouth for the admission of vibrations; the other extremity is much narrowed, and is fitted with an ear-piece, often placed at a right angle with the rest of the tube. The trumpet is made of metal, vulcanite, or horn; the large extremity is often cut off obliquely so as to increase the size of the opening. By the aid of such an instrument many deaf persons are enabled to hear the voice of a speaker at some distance. For conversation, when the speakers are near, a flexible tube is the most convenient appliance. This has a funnel-shaped mouth-piece at one extremity, and an olive-shaped ear-piece at the other. The mouth-piece is made of vulcanite or horn, and is from two to three inches in diameter; the tube is about three feet in length. When used, the patient places the ear-piece in his meatus, and the speaker, holding the mouth-piece near his lips, pronounces the words clearly, but not with excessive loudness. Some persons hear

best when the voice of the speaker is scarcely more tha
whisper. When tinnitus is present, great care is necessary.
it is sometimes much aggravated by the use of the hearing-t
When the external meatus is very irritable and will not ad
of the introduction of the ear-piece, the latter should be sha
like a shell or small cup, so as to cover the auricle.

An instrument, termed an "otophone," has been invented
Mr. Maloney, of Washington, and is declared by Dr. C.
Burnett* to be the most useful ear-trumpet presented to
notice. It succeeds where other forms fail. It does not fit
the meatus: the aural end is supplied with a disk, which is l
to the ear, this arrangement preventing irritation of the ca
Besides the trumpet, Mr. Maloney has devised a disk, which
fastened to the auricle by a locking device, kept in place by
tragus, antitragus, and concha." This instrument appears to
by enlarging the space between the helix and tragus.

A small instrument for insertion into the meatus has b
constructed by Politzer,† who claims that it improves the hea
in a considerable number of deaf persons. Its principle is b
upon the fact that a sound acting upon the ear is heard n
loudly when the surface of the tragus is enlarged backwards
the application of a small firm plate. When the instrument i
position, an increased number of vibrations are conducted to
auditory meatus.

The instrument is shaped like a hunting-horn; its narro
inner extremity is inserted into the auditory meatus, the o
larger part lies on the auricle, with the opening directed b
wards towards the concha. Three sizes are sufficient for all ca
and vulcanite, coloured red, is the best material. The in
portion of the tube is removed to the extent of about one-t
of the circumference. The instrument is passed into the mea
with the wider opening pointing upwards; and then turned
that the same opening looks backwards towards the con
According to Politzer's experiments, when this instrument
worn, the hearing-distance is, on an average, doubled; tho
in about one-fourth of the cases no change results, and in s
the hearing-distance is lessened.

Another instrument, devised by the same authority, has for object the communication of the vibrations of the auricular cartilage to the membrana tympani by means of an elastic conductor. This consists of a piece of rubber tubing, 4—5cm. (about 2 inches) long and 2mm. (about $\frac{1}{12}$ inch) thick, with its inner end cut obliquely, and resting against the membrana tympani. The outer end is curved, so as to fit into the concha: the effect is increased by passing it through a little round disk of vulcanite, which lies in the hollow.

---

* *Archives of Otology*, vol. xvi. p. 177.

† *Lehrbuch der Ohrenheilkunde*, 2 Aufl. S. 554.

An instrument termed the "audiphone," invented by Mr. Rhodes, of Chicago, is designed to conduct sounds through the bones of the head, and thereby improve the hearing. It consists of a flexible plate of vulcanite or well-lacquered pasteboard, 10 to 12 inches long and rather less in breadth, and somewhat resembling a fan in shape. There is a handle at the lower border, while the opposite edge has a small metal plate, which is applied to the teeth or zygoma. In one modification, the audiphone is constructed of several pieces, jointed together, and made to assume the necessary curve by means of a silken cord. The instrument is applied to the upper incisor teeth, with its convexity directed forwards; sound-waves impinging upon it are conducted to the bones of the head and the labyrinth. The audiphone is easily held, and is less conspicuous than an ear-trumpet: it is, however, less useful than the latter in the majority of cases.

Paladino's instrument, the "fonifero," is designed to conduct sounds directly from the larynx of the speaker to the teeth or external meatus of the hearer. It consists of a straight rod 18 to 25 inches in length, having at one end a thin semicircular metallic band, and at the other a small metal plate. The former is applied to the skin over the larynx.

In some cases the best conversation-tube is found to be a single piece of india-rubber tubing with a hollow piece of vulcanite at one end to fit into the meatus, and a small cup-shaped piece of vulcanite at the other end to collect the sound. If the meatus is irritable, a disk about an inch and a-half in diameter, and perforated in its centre, may be fixed on the aural end of the tube in the place of the vulcanite plug.

With regard to all these instruments, it would seem that the hearing-trumpets are more generally useful than any other contrivance. They must always be tested by the patient; it is impossible to predict the degree of assistance that will accr from any one of them. An instrument should be selected whi improves the hearing as much as possible, without irritati the meatus or causing any unpleasant sensations. Patients a generally loth to have recourse to these artificial aids until t deafness has become very serious. They should, however, advised not to wait until this stage has been reached, but use a hearing-tube or trumpet as soon as ordinary conversati is not heard so as to be clearly understood.

CHAPTER XLIX.

LIFE-ASSURANCE AND DISEASES OF THE EAR—SIMULATED DEAFNESS—HYGIENE OF THE EAR—MILITARY REGULATIONS.

Diseases of the Ear tending to Imperil or Shorten Life—Diseases of the Ear which may be regarded as unimportant with reference to Life-Assurance—Decision in Cases of Suppurative Inflammation—Simulated Deafness—Means of Testing—Hygiene of the Ear—Military Regulations in Austria and Prussia with regard to Recruits suffering from Aural Diseases.

Chronic suppuration of the middle ear is a possible source of danger to life; and though in the large majority of cases it is free from fatal consequences, yet it seldom exists for any length of time without impairing the health of the individual. It has been shown in previous chapters that caries and necrosis of the temporal bone, suppuration within the mastoid cells, meningitis, cerebral abscess, sinus thrombosis, pyæmia, and facial paralysis are some of the results of chronic suppuration in the tympanum; and on this account persons suffering from this ailment require to be very minutely examined when they present themselves for life-assurance. The mortality caused by middle-ear suppuration is much greater than would appear from the Registrar-General's returns (see page 558). It is worthy of note that the average age at which life-assurance is effected is 35 years. In the large majority of cases of middle-ear suppuration, the symptoms appear long before this age has been reached. In all serious diseases of the ear, and particularly in that one just mentioned, the question for the medical examiner to determine is whether the life should be accepted or not; and if accepted, what addition should be made to the premiums.

It is not too much to say that cases of chronic suppurativ inflammation of the tympanum should be unhesitatingly rejecte if there be a large perforation in the membrane, with granulation or polypi in the cavity. The decision becomes, if possible, mor easy if there be at the same time evidences of caries of th osseous walls, and especially of disease in the attic and antrum fistulous openings in the mastoid process, or signs of facia paralysis. The presence of exostoses in the meatus is to b considered as a decidedly unfavourable addition to chroni tympanic suppuration. In the absence of suppuration, larg exostoses with a very small opening would require carefu consideration. Small growths might be disregarded. As matter of course, any ulceration, presumably of a malignan character, affecting the auricle or meatus, will disqualify th applicant; and the same decision will be required when ther is any history of attacks of giddiness and disorders of coordination in connection with some aural disease.

Certain other conditions of the ear, inasmuch as they do no affect the general health and are not prone to be attended b dangerous complications, are of no special importance as regard life-assurance. This category includes the various cutaneou affections of the auricle and meatus—*e.g.*, eczema and furuncles and also exostoses in the canal, when unaccompanied by suppurative inflammation beyond. Chronic adhesive processes i the middle ear have no special bearing upon the question o life-assurance; and persons with cicatrices in the tympanic membrane, whether adherent or not to the inner wall, may so fa be regarded as "good lives."

When a dry perforation remains, but no discharge is visible some consideration will be required before deciding as to th eligibility of the applicant. The danger lies in a recurrence of the tympanic affection, and the risk will be considerably heightened if there be evidences of pharyngeal catarrh. Under such circumstances some addition should be made to the premium, the amount depending upon the general health and circumstances of the patient, the condition of the tympanum, so far as can be ascertained, and the state of the throat and chest.

In the case of recent suppurative inflammation within the tympanum, the decision may be postponed so as to allow time for suitable treatment to be adopted. If, after the lapse of two or three months the inflammation subside, the discharge cease, and the perforation become dry, the life may be accepted, subject to the conditions stated above. Should, however, the discharge continue and granulations form, it will be advisable in the interests of the office to decline to accept the proposal. All cases with discharge from the ear, or any history thereof, should be very carefully examined. In chronic cases, if it be evident that suitable treatment has been wanting, or only imperfectly carried out, acceptance should be refused; the applicant should be advised to undergo proper treatment, and after a sufficient interval to offer himself for re-examination. The decision will then depend upon the condition of the ear. Complete arrest of the discharge and cicatrisation of the perforation would allow the applicant to be accepted, possibly without any addition to the premium. But with unsatisfactory results of treatment, the application must be rejected, or accepted only with a considerable addition to the premium. The duration of life in such persons is below the average. Some, indeed, die at a comparatively early age, either from the direct consequences of the local affection or from some wasting disease. It must be borne in mind that many years may elapse between the first appearance of a discharge from the ear and its fatal consequences in the brain.

Risks of a different character have to be considered when the applicant for life-assurance is extremely deaf, but has never suffered from suppurative middle-ear disease. In such a case, the risk of accidents in the streets from moving vehicles and other objects is decidedly increased. The question of an addition to the premium may, however, be left to be decided by the assurance company.

SIMULATED DEAFNESS.

Dulness of hearing and complete deafness are not infrequently simulated in countries in which the inhabitants are liable to compulsory military service. The defect is sometimes pretended to exist under other circumstances, *e.g.*, when damages are claimed from a railway company for injuries alleged to have been sustained in a collision, etc.

In all cases of suspected simulation of deafness, the histor and account given by the patient should be carefully noted down The ears should next be examined, and the condition of th meatus, membrana tympani, and Eustachian tube on both side accurately determined. Dulness of hearing is more frequentl simulated than absolute deafness; and in some cases a pre existing defect is exaggerated, and alleged to disqualify th patient from following his occupation.

For unilateral deafness, supposed to be simulated, the following test should be applied:—

A plug of cotton-wool is inserted into the meatus of th normal ear and a vibrating tuning-fork is then placed on th vertex. An impostor will probably assert that he does not hea the sound at all, whereas perception must be decidedly increase in the occluded ear. He may, on the other hand, admit tha he hears the sound, though very faintly, on the deaf side. plug of cotton-wool should now be placed in that ear; th sound ought to be strengthened, and the assertion that it is n longer heard will be proof of the imposition.

The watch and speech may next be used as tests, and th following plan will serve to detect imposition:—The eyes ar covered with a bandage, and the hearing-distance for the soun ear is carefully determined. A plug of cotton-wool is the inserted into this ear, but not closely packed. When tested a before by means of the watch and speech, an impostor wi probably assert that he hears nothing, whereas the insertion o cotton-wool into the meatus affects but slightly the hearing distance of a normal ear for speech. Words uttered with moderate degree of loudness can still be heard at a distanc of several yards.

This test may be modified as follows:—The examiner explain that he wishes to introduce an india-rubber plug into the soun ear; but he uses a piece of india-rubber tubing, which fits th meatus accurately, or a plug furnished with a stopper, whic is withdrawn after insertion. Little, if any, difference will thu be effected in the hearing-power; but an impostor is likel to assert that his hearing is greatly impaired, or perhaps quit abolished.

The voice may also be utilised as a test in this way: th distance is ascertained at which spoken words can be clearl heard. The person's eyes are then bandaged, and the examiner retires to a greater distance, and utters words with the same degree of intensity. He then tests the hearing at various distances, some within and others beyond the normal distance. An impostor will get confused, and will probably assert that he fails to hear words uttered close to his ear, while those spoken at a much greater distance are admitted to be audible. There is yet another plan: the examiner, remaining in the same spot, repeats a word several times, gradually lowering his voice.

A method devised by Teuber* is very efficacious, but requires a special form of apparatus. The wall of a room is perforated by two metallic tubes, each of which is prolonged by a piece of india-rubber tubing. The latter terminates in an ear-piece for each meatus. Each india-rubber tube has a lateral branch, which is inserted into the meatus of an assistant. The examiner, who is out of sight, speaks first into one and then into the other tube: the words or sentences are of course heard by one or other assistant. If he makes rapid changes from one tube to the other, an impostor will soon get confused, and will fail to distinguish words spoken in one ear from those spoken in the other. When told to repeat what he has heard, he will prove that the ear which he declares to be deaf is capable of discharging its functions.

There is another and a more simple method, based on the same principle. A tube is inserted into each ear; the examiner speaks through one, and his assistant through the other at the same time. In a genuine case the patient will repeat only what has been spoken into the normal ear; an impostor will become confused, and will repeat words heard on the side on which he asserts that he is deaf.

A binaural stethoscope may be utilised for detecting feigned unilateral deafness. In a case in which it was tried the patient asserted that he was deaf on the left side. A tightly-fitting wooden plug was inserted into the right caoutchouc tube, and both elastic tubes were placed in the metal ones. Testing the instrument on himself, the examiner found that speech was not heard by the right ear. When the patient was thus tested, he repeated without hesitation words spoken into the funnel-shaped end of the instrument, which served as the mouth-piece. T tube containing the plug was then withdrawn from the rig meatus, which was firmly closed by pressure on the tragus. (again speaking into the stethoscope, which was still connect with the left ear, the patient positively asserted that he hea nothing. He was conscious that the tube through which he h (as he supposed) before heard was no longer connected wi the right ear.

---

* *Berlin. Klin. Woch.*, 1869, Nr. 9.

For the detection of simulated bilateral deafness a banda should be placed over the eyes, and each ear tested separately speech and the acoumeter. The patient's statements are careful noted with a view to discover contradictions. For the detecti of simulated total deafness, the person must be seen when asle and the amount of noise required to rouse him should then noticed. If placed under chloroform, so as to become on partially insensible, an impostor may answer questions put him, or show by some remark that he hears the conversati that is going on around him. It has been suggested that duri the ordinary examination a third person should make some di paraging or insulting observations with reference to the suspect impostor, while the examiner notices whether any effect is pr duced upon the features of the latter. Another suggestion of similar character is that the examiner should tell the pers that he may go, that he is unfit for work, etc. Such plan however, would fail to detect a clever impostor, who would quite prepared for any such attempts to throw him off his guar

HYGIENE OF THE EAR.

In several preceding chapters, reference has been made various measures calculated to prevent a recurrence of the di orders under consideration. Such measures constitute, inde an important part of the treatment; to neglect them would to invite not only a recurrence of the original disease, but t supervention of various complications, liable to occur aft repeated attacks and in chronic conditions of disease. It no remains to add a few remarks on the general hygiene of the e and to point out the best means of keeping the organ in healthy condition.

In early childhood the most frequent causes of ear-diseases are exposure to cold, adenoid growths in the naso-pharynx, and various infectious diseases, notably scarlatina, diphtheria, and measles. In young children, affections of the ear are specially important, for if deafness should result there is danger of losing the faculty of speech. With regard to exposure to cold, experiments have shown that not only naso-pharyngeal catarrh may thus be produced, but that, under its influence, the epithelium of the Eustachian tube offers less resistance to the passage of micro-organisms from the throat to the middle ear. Cold water, freely applied to the head and ears, has a similar effect. Hence immersion of the head during bathing is a not infrequent cause of otitis externa and media. Under such circumstances, water may also pass from the throat to the middle ear. Besides the effect of cold, there is always the possibility that the water may contain bacteria, to the action of which many cases of otitis are traceable. Risk may be averted by wearing ear-protectors (see page 366).

The ears of children should be protected from cold and wet. It should be remembered that in infants the osseous portion of the external meatus is still incomplete, and that the membrana tympani is less protected than in after life. The caps worn by infants should fit easily over the ears, and should not contain any irritating matters. A child's ears should be washed with warm water and very carefully dried. Cracks are liable to form, especially behind the auricle, and eczematous eruptions are very common. These not only cause much irritation, but may extend into the meatus. Cracks and eruptions should be dressed with boric acid ointment, or with an ointment composed of zinc oxide three parts, white vaseline seventeen parts. If the eczema be of the moist kind, it will be better to use a powder containing zinc oxide, boric acid, and starch, or in some cases starch only.

In older children, as well as in adults, the ceruminous secretion sometimes requires attention. It may accumulate in the meatus and cause deafness, noises in the ears, and local irritation of various degrees. The methods of dealing with this condition have been already described (see page 169). It is sufficient here to add that parents and nurses should be warned against the use of ear-cleansers made of bone or metal, which remove only small particles of wax, while they often injure the walls of the meatus and the membrana tympani. They sho against attempting to clean the ears by a towel or handkerchief, or using the aurilave, which consists of a globular pi to the end of a handle, and is intended to to cleanse the meatus. All these applian of the cerumen deeper into the passage, end becomes blocked with cerumen and e left to itself, the cerumen tends to pass being aided by the movements of the ja instrument for domestic use is the roun It must be used very carefully, and w withdrawn, the outer portion of the m cleaned by putting part of a wetted hand pin. Parents and nurses should be furt resorting to this practice too frequently.

It is not safe to entrust patients with cleansing the meatus; but no harm can rubber syringe. After its use, the parts dried with cotton-wool.

Children should be cautioned against i into the ears; and those in charge of t against attempts to extract any such sub tionally or accidentally inserted. Blow of course, be strictly forbidden.

Inattention among children, and what mental development, are often due to imp education of young children, much of the through the ear; and when partial deafn thereof follow the teacher with difficulty, Such children are affected more than o conditions more or less commonly pre defective acoustic arrangements of the ro talking by the master, and noises outsi hindrances aggravate the disability, and regarded as backward, and perhaps punish the defect is unilateral, the deafness ma

Statistics with regard to the prevalen children attending school give very differ places, the extremes being 2 and 30 per c main causes of deafness are stated to be as follows: morbid conditions of the organ of hearing as the result of dirty habits; adenoid growths in the naso-pharynx; infectious diseases; naso-pharyngeal catarrh; exposure to cold; concussion caused by loud sounds; blows on the ear; foreign bodies in the meatus; rough attempts at cleaning the parts. The frequency of aural diseases among the poorer classes is due to neglect by the parents and want of proper medical aid.

The educational work at school cannot be charged with the production of aural disease or with the aggravation of any that may exist; but deaf children should be separated from others and afforded every facility for hearing the master's instructions. The parents should be exhorted to obtain proper treatment for such children, and warned as to the consequences of neglect. Moreover, children apparently dull and stupid, keeping their mouths constantly open, and having prominent and expressionless lips, should be examined by a medical man in order to discover whether adenoid growths exist in the naso-pharynx. Otorrhœa should never be neglected; its significance is rarely appreciated by those in charge of children. As a general rule, the proportion of cures, in cases of aural disease, is in inverse ratio to the age of the patients. Parents either do nothing, or take their children to chemists, who often prescribe oils, which are always useless and sometimes injurious.

In order to test a child's hearing, the usual methods should be adopted (see page 91). If whispered speech be heard at a distance of 12 feet, the hearing may be pronounced normal; but if at only half that distance, such a child is very disadvantageously placed as regards instruction. In estimating the hearing-power, account must be taken of the intelligence of the child, the acoustic arrangements of the room, the voice of the teacher, and the character of the surroundings, whether quiet or otherwise. A schoolmaster should occasionally admonish the children as to the care of the ears, and should warn them against injuring the meatus by inserting pieces of wood (whether for cleansing or other purposes), peas, beans, and the like. The danger of blows on the ears should be pointed out; rupture of the membrane may result or may be attributed to such a cause. Pulling the auricle should likewise be forbidden.

In adults, ear-diseases appearing for the first time are most [illegible] similar [illegible] consequences [illegible] consequences.

The effects of [illegible] upon the ear have already been refer [illegible] in the meatus, and [illegible] inflammation which may spread to the [illegible]

[illegible] the danger of setting [illegible] as [illegible] sewage. The [illegible] and if sea-water [illegible] the part should be carefi [illegible] after which boric [illegible]

AUSTRIAN AND PRUSSIAN REGULATIONS WITH REGAR TO THE HEARING OF RECRUITS.

The following regulations are in force in Austria and Pru with regard to the fitness for service of recruits with any a affection:—

In Austria the following conditions do not constitute unfit for service:—

(*a*) Reduction of hearing-power of both ears to a distance 8 metres (26 feet). Clearly-uttered whispers, by a person normal hearing, must be heard, so that the words can be repeat at a distance of 2 metres (6½ feet), in a moderately still and qu place.

(*b*) Reduction of hearing-power in one ear to a distar of 4 metres (13 feet), the hearing on the other side being normal.

(*c*) Partial loss of one auricle, malformations, and non-malignant growths of the external ear, with hearing-power as laid down under *a* and *b*.

(*d*) Congenital or acquired stenoses of the external meatus, the morbid process which was the cause thereof having come to a standstill, and the hearing-distance being not less than that described above.

(*e*) With a hearing-distance as above, the following affections of the external and middle ear and their consequences do not, *per se*, cause unfitness: plugs of cerumen, exostoses, constrictions, cicatrices, calcareous deposits, and retractions of the membrana tympani; all forms of simple catarrhal inflammation, together with any resulting adhesive processes.

The following conditions render a man fit only for sanitary duties, care of the sick, and charge of clothing:—

(*a*) Deafness on both sides, with a hearing-distance up to 4 metres (13 feet).

(*b*) Deafness on one side, with a hearing-distance up to 2 metres (6½ feet), and perfect hearing on the other.

(*c*) Partial loss of one auricle, malformations, and non-malignant growths of the external ear, with the hearing-distance as above.

(*d*) Congenital or acquired stenoses of the meatus, with no signs of active disease, the hearing-distance being as above.

(*e*) Affections of the external and middle ear and their consequences, not *per se* causing unfitness, with a hearing-distance as above.

The following conditions unfit for active service, in some cases, after repeated testing; in others, at once and as a matter of course:—

(*a*) Deafness on both sides, with a hearing-distance under 4 metres (13 feet).

(*b*) Deafness on one side, with a hearing-distance under 2 metres (6½ feet).

(*c*) Chronic perforation of the membrana tympani.

(*d*) All forms of chronic suppurative inflammation in the middle ear, with their complications.

(*e*) Loss of one auricle.

(*f*) Congenital or acquired total closure of the extern meatus, even if unilateral.

For service in the Landsturm a man is still fit who has—

(*a*) Loss of one auricle.

(*b*) Chronic perforation of the membrane, with hearin distance of about 2 metres (6½ feet).

The following conditions disqualify a man for active servi but not for mechanical work connected with warlike operations:

(*a*) Deafness on both sides, with a hearing-distance bel 4 metres (13 feet), but such as does not unfit for ordinary wo

(*b*) Congenital or acquired total closure of the external mea on one side.

(*c*) A permanent opening in the membrane, the defect preventing ordinary employment.

(*d*) All forms of chronic suppurative inflammation in middle ear, with their complications, so long as they do hinder ordinary work.

Congenital or acquired total closure of the meatus on b sides constitutes a complete disqualification.

In Prussia, temporary unfitness is caused by inflammation the meatus.

Unfitness for active service is caused by the following co ditions, when of a permanent character:—

(*a*) Chronic impairment of hearing, to a moderate extent, both ears.

(*b*) Unilateral deafness, with no signs of active disease.

Permanent unfitness is caused by:—

(*a*) Absence of one auricle.

(*b*) Deafness or incurable severe impairment of hearing both sides.

(*c*) Permanent perforation of the membrane and other i curable diseases of the ear, of a serious character.

INDEX.

PAGE
Abscess, cerebral, from middle-ear suppuration 566
———— appearances of . . . 570
———— diagnosis of 571
———— optic neuritis in . . . 567
———— seats of 568
———— stages of morbid processes in 570
———— temperature of patients suffering from 568
———— treatment of 572
Abscesses, gravitation, from disease of mastoid process . . . 536
Acoumeter, Politzer's, for testing hearing-power 93
Acoustic anæsthesia 738
——— hyperæsthesia 682, 735
Adenoid growths in naso-pharynx 300
———— anæsthetics necessary for operations on 310, 314
———— aprosexia as a symptom of 303
———— as a cause of middle-ear catarrh . . . 301
———— author's forceps for removal of . . . 319
———— causes of 301
———— cervical adenitis due to 305
———— diagnosis of 306
———— digital examination of 306
———— Dr. Hewitt on anæsthetics in operations upon 310
———— finger-guard, author's, for examination of . 115
———— hæmorrhage, arrest of, after operations upon 321
———— instruments for removal of 318
———— management of patients after operations on 316
———— mirror, use of, in examining 307
———— position of patient during operations on . 312
———— preparation of patients for operations on . 311
———— structure of 301
———— symptoms of 302
———— treatment of 308
Adherent cicatrices of the tympanic membrane 480
Adhesions between tympanic membrane and inner wall . . . 478

PA

Affections, local and general, causing disorders of hearing . . 5
Age, bone-conduction lessened in advanced. 1
—— influence of, in causation of aural diseases . . . . . .
Air, compressed, action of, on Eustachian tube and middle ear. . 1
—— injection of, into tympanum, results of. 1
—— methods of injecting, into Eustachian tube and tympanum . 1
Air-bag, author's, for using in Politzer's method. 1
Air-douche for Eustachian tube and tympanum 1
Alcohol as an application to aural polypi 5
—————— granulations in tympanum . . . 4
Anæmia, cerebral, as a cause of disorder of hearing 5
——— of labyrinth 6
Anæsthesia of auditory nerve 7
Anæsthetics, use of, during removal of adenoid growths . . . 3
Anatomy and physiology of sound-conducting apparatus . . .
Angio-fibromatous polypus of the ear 4
Angioma of external ear 2
Antiseptic remedies in chronic middle-ear suppuration . . . 4
Antrum, mastoid, anatomy of . . . .
—————— operations on 5
Aprosexia as a symptom of adenoid growths 3
Artificial tympanic membranes 4
—————— *modus operandi*, and indications for use of . 4
Aspergillus (parasites) in external meatus 2
—————— microscopical appearances of. 2
Attic of tympanum, anatomy of . . . .
—————— suppuration in 4
—————— treatment of 5
"Audiphone," Rhodes', for relief of deafness 7
Auditory area. 6
——— hallucinations 7
——— nerve, anæsthesia of 7
—————— as result of employment 7
————— effect of electricity upon 7
————— hyperacusis of 7
————— hyperæsthesia of 7
————— neuroses of 7
————— new formations connected with 7
————— origin of 6
——— sensations, subjective, causes of 7
—————— difference between, and entotic noises . . 7
—————— due to reflex action. 7
—————— effects of. 7
—————— peculiarities of 7
—————— prognosis and treatment of 7
Aural diseases, general methods of treatment of 1
——— douche, Fayette Taylor's 1
——— polypi 4
——— reflexes from cerumen in meatus 1

PAGE
Auricle, abnormal position of 164
——— abnormal size and shape of 164
——— absence of 162
——— acoustic potentials of 9
——— anatomy of 4
——— angioma of 222
——— burns and scalds of 179
——— cysts of 224
——— diseases of 162
——— eczema of 189
——— epithelioma of 227
——— fibroma of 224
——— fistulæ (congenital) of 167
——— frost-bite of 179
——— functions of 6
——— herpes of 188
——— incomplete development of 162
——— injuries to 177
——— lupus of 228
——— muscles of 5
——— new formations of 222
——— othæmatoma of 181
——— perichondritis of 186
——— projection of, from side of head 164
——— sarcoma of 225
——— syphilitic affections of 218
——— vessels and nerves of 5
Auricles, supernumerary 163
Auriscope, Brunton's, description and use of 83
Auscultation-tube, use of, when forcing air into Eustachian tube . 120
Austria and Prussia, regulations as to hearing of recruits in . . 782
Auto-insufflator for meatus, author's 156
Autophony as a symptom of chronic middle-ear catarrh . . . 359
——————— of patency of Eustachian tube 330

Ballance, C. A., grafting operation devised by, to cover in opening
made in mastoid process 551
——————— thrombosis of sigmoid sinus 583
Berthold, Prof., myringo-plastic operations 468
Blistering fluid, best form of, for application to mastoid process . 349
Blood, local abstraction of, as a method of treatment 151
Blood-tumours of auricle 181
Bone-conduction of sounds lessened in old age 105
————————— modes of testing 99
————————————————— in labyrinthine affections 686
Boric acid as an application in chronic middle-ear suppuration . 450
Bougies, Eustachian, author's views as to drawbacks connected with
use of 140
——————— passage of 140

PAG

Brain, syphilitic growths in, involving auditory nerve . . . 59
——— tumours of, causing deafness 59
Brenner and Erb on effects of galvanism on auditory nerve . . 75
"Bristle-cells" in cristæ acusticæ 65
Brown, Gardiner, acoustic potentials of auricle . . . . . .
——————— ear-syringe 14
——————— ear-trough 14
——————— hand-mirror 8
——————— tuning-fork for testing bone-conduction of sound . 10
Brunton's auriscope 8
Bull, Dr. Ole, on treatment of caries and necrosis of temporal bone by application of mineral acids 52
Burckhardt-Merian on otitis media and scarlatina 60
Burns and scalds of external ear 17

Caisson-disease, effects of compressed air on ear 25
Calcareous deposits in tympanic membrane 47
Canals, semicircular 64
Caries and necrosis of temporal bone 51
——————————————— course of 51
——————————————— diagnosis of 51
——————————————— discharge from ear in . . 51
——————————————— lesions of facial nerve in . . 51
——————————————— objective symptoms of . . 51
——————————————— perversions of taste in . . 51
——————————————— prognosis of 51
——————————————— subjective symptoms of . . 51
——————————————— treatment of 51
Caries of the ossicles 51
————————— treatment of 52
Carotid artery, ulceration of coats of, from middle-ear suppuration . 58
———————— diagnosis and treatment of 59
Caustic remedies in chronic middle-ear suppuration 45
——————— in treatment of aural polypi 50
Cautery, forms of, in treatment of naso-pharyngeal catarrh . . 28
Cavernous angioma of auricle 22
————————— labyrinth 71
Cerebellar affections, contrasted with disorders of labyrinth . . 68
Cerebellum, abscess of, from middle-ear suppuration . . . 56
Cerebral blood-vessels, lesions of, causing aural disorder . . . 59
Cerebral meningitis, from middle-ear suppuration 56
Cerebro-spinal fluid, escape of, in injuries to tympanum . . 253, 63
Cerebrum, abscess of, from middle-ear suppuration 56
Cerumen, accumulation of 16
———————— symptoms of 17
———————— treatment of 17
——— deficiency of 17
Ceruminous glands of meatus 1

PAGE
Chain-makers, defective hearing-power of 741
Chair, author's revolving, for aural cases 128
Children, new-born, meatus in 17
Cheatle, A. H., on anatomy of mastoid antrum 63
Chloride of ammonium, injection of vapour of, through Eustachian tube 159
Cholesteatoma in tympanic cavity, diagnosis of 489
——— formation of 485
——— nature and pathology of 486
——— prognosis of 489
——— symptoms and consequences of 488
——— treatment of 489
Chromic acid, application of, to naso-pharynx 283
——— carrier 283
——— for destruction of aural polypi 506
——— use of, in chronic middle-ear suppuration . . . 453
Cicatrices of membrana tympani 460
Cochlea, description of 650, 653
——— functions of 664
Cochlear branch of auditory nerve 653
Cold, application of, to ear 150
Condensed air, causing rupture of tympanic membrane . . . 253
Conditions in tympanum facilitating cranial lesions 559
Condylomata of external ear 218
Cone of light, description of 88
Consequences of middle-ear suppuration 484
Constitutional treatment of aural diseases 160
Conversation-tubes for deaf persons 769
Co-ordination, disorders of, in affections of internal ear . . . 678
Corti's cells and pillars, description of 656
——— organ 655
Cousins, Dr. Ward, ear-protectors 366
——— extractor, for foreign bodies 248
Cranial complications of middle-ear suppuration 557
Cristæ acusticæ 652
Croupous and diphtheritic inflammation of external ear . . . 208
——— middle ear . . . 600
——— micro-organisms in . 601
——— symptoms and prognosis of . 602
Cysts of auricle 224

Deaf and dumb in United Kingdom, statistics of 759
Deaf-mutism, acquired form of 762
——— causes of 760
——— classes and statistics of 759
——— diagnosis of 762
——— Dr. Francis Warner's statistics of 760
——— pathological appearances in cases of 761

Deaf-mutism, prognosis and treatment of .
——— Urbantschitsch's method of treat
Deafness as a symptom of diseases of internal e
——— simulated, detection of . . .
Dean, H. P., operation for intracranial compli
disease . . . .
Delstanche's *masseur*, for rarefaction of air in
Dental drill, for removing exostosis from meat
Diabetes associated with aural diseases .
Diffuse inflammation of external meatus .
——— treatment of
Diphtheritic inflammation of external meatus
——— middle ear .
Discharges from the meatus as a symptom of di
Diseases of ear and life-assurance . .
Double hearing, explanation of phenomena of
Douche, aural, Fayette Taylor's . . .
Drugs, various, effect of, upon organ of hearing
Duchenne on use of induced current for nervous

Ear, discharges from . . . . . .
—— examination of . . . . . .
—— foreign bodies in . . . . . .
——— instruments for removal
——— symptoms caused by .
——— treatment of .
—— hygiene of . . . . . .
—— insects in . . . .
—— watery discharge from, after injuries to h
Ear-protectors, Ward Cousins' . . .
Ear-syringe, best form of . . . .
——— method of using . . .
Ear-trough, Gardiner Brown's . . .
Ear-trumpet, desirability of early use of .
——trumpets, forms of . . . . .
Eczema of auricle and meatus . . .
——— treatment of
Electricity in treatment of aural diseases .
Electrode-handle, for cautery, author's .
Electrodes, aural and pharyngeal, author's .
Emphysema sometimes caused by use of Eustac
Engine-drivers, defective hearing-power of .
Entotic sounds . . . .
Epithelioma of external ear . . . . .
——— labyrinth . . . .
Eustachian catheters, auscultation-tube during
——— bags for injecting air through
——— disinfection of . . . .

PAGE
Eustachian catheters, emphysema sometimes caused by use of . 134
——— forms and description of 122
——— Frank and Gruber's methods of introducing . . 132
——— indications for use of 139
——— introduction of 127
——— method of measuring, devised by author . . 123
——— mistakes usually made in passing 127
——— obstacles to passage of, sometimes met with . . 132
——— position of hand during introduction of . . . 130
——— risks of conveying syphilis by 125
——— sounds caused during injection of air by . . 135
——— use of cocaine-spray before introducing . . . 134
——— value of use of, contrasted with Valsalva's and Politzer's methods 139
——— with copper collars, for use in syphilitic cases . 125
Eustachian tube, action of compressed air upon 136
——— affections of 323
——— anatomy of 50
——— atresia of 329
——— bougies for passage along 140
——— cartilaginous portion of 52
——— catheter for testing permeability 122
——— constrictions of 328
——— examination of 115
——— fasciæ and ligaments of 58
——— folds in mucous membrane of 53
——— foreign bodies in 324
——— functions of 59
——— in children 56
——— inflammation of 325
——— injection of fluids through 156
——— ——— gases and vapours through . . . 159
——— injuries to 324
——— membranous portion of 53
——— mucous lining of 54
——— muscles of 56
——— nerves of 59
——— osseous portion of 51
——— passage of bougies along 140
——— ——— catheters along 127
——— pharyngeal opening of 55
——— ——— as seen in posterior rhinoscopy . 112
——— Politzer's method of injecting air into . . . 117
——— ——— ——— author's air-bag for use in . 126
——— ——— ——— modifications of 119
——— state of, in chronic adhesive catarrh . . . 375
——— swallowing, effects of, upon 55
——— syphilitic affections of 331

PAGE
Eustachian tube, tissues in contact with cartilaginous portion of . . 55
———— ulceration of 330
———— undue patency of 330
———— Valsalva's method of forcing air through . . 116
———— vessels of 58
———— walls of 51
Examination of ear 78
———— nose, pharynx, and Eustachian tubes . . . 106
———— patients suffering from aural diseases . . . 69
Exostoses of external meatus 230
—————— as affecting conditions of life-assurance . . 774
—————— treatment of 233
External conditions as causes of aural disease 73
——— meatus, accumulation of cerumen in 169
———— anatomy of 10
———— angioma of 222
———— ceruminous glands of 15
———— croupous and diphtheritic inflammation of . . 208
———— deficiency of cerumen in 174
———— diffuse inflammation of 203
———— disorders of secretion in 169
———— eczema of 189
———— epithelioma of 227
———— exostoses of 230
———————— removal of 233
—————— pedunculated, removal of 235
———— foreign bodies in 239
———— fracture of walls of 178
———— functions of 18
———— furuncular inflammation of 195
—————————— micrococci in 195
———— herpes of 188
———— in the fœtus at ninth month 17
———— injuries of 178
———— insufflation of powders into 155
———— integument and glands of 15
———— introduction of medicated solutions into . . . 154
———— keratosis obturans of 174
———— lupus of 228
———— malformations of 162
———— measurements of 11
———— method of cleansing 780
———— new formations of 222
———— osteomata of 229
———— parasitic inflammation of. 211
———— relations of 13
———— sarcoma of 225
———— sections through 10, 12
———— vessels and nerves of 17

PAGE
Facial nerve, lesions of, in caries and necrosis of temporal bone 514, 713
Fagge, Dr. Hilton, on pathology of Ménière's disease 728
Fibroma of auricle 224
Fibrous polypi of ear 493
Finger-guard, author's, for examination of naso-pharynx 115
Flourens' experiments on semicircular canals 661
Fluids, injection of, through Eustachian tube 157
Fœtus, purulent collections in tympanum of 427
"Fonifero," Paladino's, for relief of deafness 771
Forceps, author's, for removal of post-nasal growths 319
——— crocodile-mouthed, for removing cerumen from meatus . 82
Foreign bodies in ear 239
Fracture of petrous bone, watery discharge from ear in . . . 638
Frost-bite of auricle 179
Fumigator, for applying calomel to nostrils 281
Furuncular inflammation of external meatus 195
——————————— treatment of . . . 199

Galton's whistle, for testing with high notes 95, 691
Galvanism in treatment of aural diseases 754
Gellé, method of distinguishing between internal and middle-ear affections 104
Glioma of labyrinth 718
Granular pharyngitis, treatment of 295
Gruber, Prof., artificial tympanic membrane 470
————— modification of Rinne's test 103
————— pathology of Ménière's disease 729
Gummata of external ear 224
Guye, Dr., on aprosexia as a symptom of adenoid growths . . . 303

Habits and surroundings as causes of aural diseases 71
Hæmorrhage, arrest of, after operations on adenoid growths . . 321
————————— tonsillotomy 293
————— from tympanum 639
Hartmann, Dr., artificial membrana tympani 471
————— statistics of deaf-mutism 760
Haug, Dr., on aural complications of influenza at Munich . . . 617
Hearing, artificial aids to 769
——— defective, resulting from employments 741
——— examination of organ of 78
——— general sketch of organ of 1
——— main divisions of organ of 2
——— organ of, in lower animals 2
Hearing-power, acoumeter (Politzer's) as a test of 93
————— determination of 91
————— formula for registering 92
————— sonometer (Hughes') for testing 95
————— speech for testing 96

PAGE
Hearing-power, tuning-fork as a test of . . . 98
——— watch as a test of . . . 91
——— whispers for testing . . . 97
——— whistle (Galton's) for testing . . . 95
——— words to be used in testing . . . 97
Heat and cold, application of, to ear . . . 149
Heredity as a cause of aural diseases . . . 73
——— deaf-mutism . . . 760
Herpes of auricle and meatus . . . 188
Hewett, Sir P., on watery discharges from ear after injuries to head . 637
Hewitt, Dr., general anæsthesia in nasal and naso-pharyngeal operations . . . *See note* 310
Hodgson, Mr. G. F., shortened form of Eustachian catheter . . . 123
Hommel's method for condensing and rarefying air in meatus . . . 387
Hutchinson, Mr., on syphilitic affections of the ear . . . 721
Hydrocephalus, acute, as a cause of aural disease . . . 598
Hygiene of ear . . . 778
Hyperacusis of Willis . . . 737
Hyperæmia, cerebral, as a cause of disorders of hearing . . . 594
——— of labyrinth . . . 695
Hyperæsthesia of auditory nerve . . . 682, 735
Hypertrophic rhinitis, treatment of . . . 321

Illumination of ear, means of . . . 78
——— lamps for . . . 79
Incus, description of . . . 36
Induced current, employment of, in nervous deafness . . . 756
Inferior turbinate body, hypertrophy of posterior extremity of . . . 284
Influenza, aural diseases connected with . . . 614
——— hæmorrhagic type of ear-disease in . . . 618
——— micro-organisms in blood in . . . 616
——— ——— ear in . . . 615
——— nervous, aural complications of . . . 619
——— perforation of tympanic membrane in . . . 619
Injuries as causes of aural diseases . . . 72
——— of labyrinth . . . 704
——— membrana tympani . . . 249
——— tympanum . . . 635
Insects in external meatus . . . 240
Insufflation as a method of applying remedies to meatus and tympanum . . . 155
——— ——— nose and naso-pharynx . . . 279
Insufflator, Kabierskie's, for treatment of naso-pharyngeal catarrh . 280
Internal ear, acoustic hyperæsthesia as symptom of disease of . 682, 735
——— anæmia of . . . 694
——— ——— treatment of . . . 696
——— anatomy and physiology of . . . 648
——— blood-vessels of . . . 658

PAGE
Internal ear, bone-conduction in diseases of 685
caries and necrosis of 710
causes and symptoms of 711
characters of sequestra in 714
disturbances of equilibrium in . . . 712
involvement of facial nerve in . . . 713
prognosis and treatment of. 714
——— causes of diseases of 668
——— cavernous angioma of 719
——— concussion of 704
———— diagnosis of 705
———— prognosis of 706
———— treatment of 707
——— deafness as a symptom of diseases of 674
——— diagnosis of diseases of 682
——— diphtheria of 700
——— diseases of 668
————— due to extension from neighbouring parts . . 672
—————— external influences 673
——— disorders of circulation in 694
——— effect of drugs upon 671
——— epithelioma of 717
——— examination of tympanic membrane and Eustachian tube in disease of 683
——— Galton's whistle for diagnosis of diseases of . . . 95, 691
——— giddiness and disorders of co-ordination as symptoms of diseases of 678
——— glioma of 718
——— hearing-power, examination of, in diseases of. . . . 684
——— hyperæmia of 695
treatment of 696
——— inflammation of 697
causes of. 699
in cerebro-spinal meningitis 702
prognosis and treatment of 702
symptoms of 701
injuries to 707
symptoms and treatment of 709
——— König's rods in diagnosis of diseases of 691
——— nausea and vomiting as symptoms of diseases of . . 680
——— new formations in 716
——— prognosis of diseases of 682
——— Rinne's test in diagnosis of diseases of 686
——— sarcoma of 717
——— symptoms of diseases of 674
——— contrasted with those of cerebellar affections 681
——— syphilitic affections of 720
——— syphilitic (hereditary) affections of 721

PAGE

Internal ear, tuning-forks in diagnosis of diseases of 685
Intracranial lesions resulting from middle-ear suppuration . . 557
Intratympanic irrigator 446
Iodide of potassium, administration of, causing paracusis . . . 676

Kabierskie's insufflator 280
Kanthack, Dr., on micro-organisms in acute middle-ear catarrh . . 339
Kessel on indications for tenotomy of tensor tympani . . . 399
Klebs on micro-organisms of influenza 616
König's rods in diagnosis of labyrinthine diseases 691
Körner, Prof., on multiplicity of cerebral abscesses 569
Keratosis obturans of external meatus 174

Labyrinth, anæmia of 694
——— diseases of (*see* Internal ear).
——— hyperæmia of 695
——— inflammation of 697
——— physiology of 659
Lamps for examination of ear 78
—— Mackenzie's rack-movement, author's modification of . . 79
—— portable, author's 80
Lateral (sigmoid) sinus, exposure of, in operations on mastoid process 554
——— phlebitis and thrombosis of, as results of middle-ear suppuration . 576
——— diagnosis of 582
——— symptoms of 579
——— treatment of 583
Lebert, Prof., cases of cerebral abscess 569
Leeches, use of, in treatment of ear-diseases 151
Leiter's apparatus for applying cold to mastoid process . . . 150
Lepto-meningitis, due to middle-ear disease 563
Life-assurance and aural diseases 773
Lucae's spring-pressure probe in treatment of chronic adhesive catarrh 387
Lupus of external ear 228

Macewen, Dr., on communications between tympanum and other parts 30
——— complications of middle-ear suppuration . 560, 568
——— method of reaching mastoid antrum . . . 66
——— symptoms of thrombosis of sigmoid sinus . . 579
Maculæ acusticæ 652
——— termination of nerves in 653
Malaria, as a cause of aural diseases 625
Malleus, description of 35
——— division of anterior ligament of, for chronic adhesive catarrh 396
Marriages, consanguineous, as a cause of deaf-mutism . . . 760
Massage of the auricle as a method of treatment 153
Mastoid antrum, anatomy of 62
——— effects of opening 555

PAGE
Mastoid antrum, opening of 66, 538, 544
—— cells, abscess in 532
———— anatomical description of 63
———— functions of 67
———— inflammation of 530
—————— morbid appearances of 532
—————— symptoms of 533
———— variations in 63, 527
—— portion of temporal bone, anatomy of 61
———————— antrum of 62
———————— cells of 63
———————— function of cells of 67
———————— relation of cells and antrum of 65, 543
—— process, affections of 527
———— anatomical relations of 543
———— caries and necrosis of 535
—————— course of 536
—————— prognosis of 537
—————— treatment of 537
———— formation of flap to line cavity, after operations on 549
———— gravitation abscesses as results of suppuration in 536
———— inflammation of 528
———— Leiter's apparatus for applying cold to 150
———— occasional difficulties in opening 547
———— opening of, in acute suppuration 538
—————— chronic —— 539
———— operations upon 538, 544
———— periostitis of 528
—————— treatment of 530
———— results and prognosis of operations upon 555
———— skin-grafting after operations on 551
Measles, affections of labyrinth due to 609
—— diseases of ear during course of 607
Meatus, external auditory, anatomy of 10
———— diseases of 162
———— hæmorrhage from, in neurotic subjects 739
Medicated solutions, introduction of, into meatus 154
Membrana basilaris of Corti's organ 655
—— tympani, abscesses in 261
———— acute inflammation of 259
———— adherent to inner wall 478
———— adhesions between, and wall of tympanum 478
—————— treatment of 480
———— anatomy of 22
———— artificial 469
———— artificial perforation of, methods of effecting 393
———— as seen through speculum 23, 87
———— atrophy of 477
———— calcareous deposits in 474

PA

Membrana tympani, changes in, in various aural affections . . 4
—— chronic inflammation of 2
—— cicatrices of 4
—— —— treatment of 4
—— colour of . . . .
—— consequences of adhesions of 4
—— divisions of . . . .
—— effects of condensed air upon 2
—— escape of cerebro-spinal fluid as a symptom of injuries of 2
—— examination of . . . .
—— excision of, for relief of chronic adhesive catarrh 3
—— formation of abscesses in 2
—— functions of . . . .
—— injuries of 2
—— layers of . . . .
—— mechanical injuries to head involving rupture of 2
—— mobility of, method of testing . . . .
—— operative treatment of adhesions of . . . 4
—— outer surface of . . . .
—— perforation of, in acute middle-ear catarrh . 3
—— —— —— suppuration 4
—— —— chronic —— 4
—— —— influenza 6
—— —— methods of closing . . . 4
—— persistent perforation of 4
—— —— shape and appearances of 4
—— rupture of, by *contrecoup* 2
—— —— from condensed air 2
—— —— on both sides 2
—— state of, in acute middle-ear catarrh . . . 3
—— —— —— suppuration . . 4
—— —— chronic adhesive catarrh . . . 3
—— —— —— middle-ear catarrh . . 3
—— —— —— suppuration . 4
—— symptoms caused by rupture of 2
—— thickening of 4
—— treatment of injuries of 2
—— vesicles, formation of, in 2
—— vessels and nerves of . . . .
Ménière's disease 7
—— diagnosis of 7
—— pathology of 7
—— symptoms of 7
—— treatment of 7
Meningitis, cerebral, from middle-ear suppuration 5
—— —— diagnosis and treatment of 5
—— —— symptoms of . . . 5
—— cerebro-spinal, as a cause of diseases of the ear . . 5

PAGE
Methods of inflating middle ear, comparative value of 138
Meyer, Dr. W., on adenoid growths in naso-pharynx 300
Micro-organisms in acute middle-ear suppuration 404
———— chronic ———— 431
———— tympanic exudations 339
Middle ear or tympanum, action of compressed air upon 136
———— acute catarrh of 337
—————— adenoid growths as causes of 338
—————— diagnosis and prognosis of 347
—————— effects of injection of air in . . . 347, 349
—————— micro-organisms as causes of 339
—————— morbid appearances in 342
—————— objective symptoms of 344
—————— paracentesis for 351
—————— spontaneous perforation of membrane in . 353
—————— state of tympanic membrane in 345
—————— subjective symptoms of 343
—————— treatment of 348
——————— cases of, after perforation 353
———— acute suppurative inflammation of 403
———————— boric acid, use of, in . . . 420
———————— causes of 403
———————— course and results of . . . 412
———————— diagnosis of 414
———————— foreign bodies as causes of . 405
———————— infectious diseases as causes of 404, 406
———————— micro-organisms found in . 404
———————— objective symptoms of . . 408
———————— paracentesis in treatment of. 417
———————— perforation of tympanic membrane in 409
———————— Politzer's method, use of, in . 419
———————— prognosis of 415
———————— secretion, character of, in . 411
———————— Shrapnell's membrane, perforation of, in 410
———————— symptoms of 407
———————— tinnitus as a symptom of . 408
———————— treatment of 416
———— anatomy of 21
———— anterior and posterior walls of 29
——— chronic adhesive catarrh of 367
——————— application of remedies to tympanum in 383
——————— artificial perforation of membrane for relief of 393
——————— causes of 371
——————— changes in Eustachian tube in. 370, 375

PAGE

Middle ear, chronic adhesive catarrh of, course of 377
———————— diagnosis of 379
———————— division of anterior ligament of malleus for relief of . . . 396
———————— division of posterior fold of tympanic membrane for relief of . . . 394
———————— division of tensor tympani tendon for relief of 398
———————— excision of membrana tympani and ossicles for relief of . . . 390
———————— excision of stapes for relief of . . 392
———————— multiple incisions into membrane for relief of 396
———————— naso-pharynx, state of, in . . 375
———————— objective symptoms of . . . 373
———————— operations for relief of . . . 390
———————— paracusis Willisii as a symptom of . 373
———————— pathological appearances of . . 368
———————— pepsin and papain applied to tympanum in treatment of . . . 385
———————— prognosis of 381
———————— symptoms of 371
———————— rarefaction of air in external meatus in treatment of 386
———————— tests for hearing-power in . . 376
———————— tinnitus as a symptom of . . . 372
———————— treatment of 382
———————— tympanic membrane, state of, in . 373
———— chronic catarrh of 355
——————— anatomical appearances of 356
——————— autophony in 359
——————— bone-conduction in 361
——————— causes of 356
——————— course of 362
——————— diagnosis and prognosis of 362
——————— giddiness in 359
——————— objective appearances in 359
——————— paracentesis for relief of 365
——————— subjective symptoms of 357
——————— tinnitus as a symptom of 358
——————— treatment of 363
———— chronic suppurative inflammation of 423
————————— alcohol, application of, in . . 454
————————— antiseptics and astringents in local treatment of . . . 450, 455
————————— attic implicated in 436
————————— boric acid in treatment of . . 450
————————— causes of 427
————————— caustics in treatment of . . 453

PAGE

Middle ear, chronic suppurative inflammation of, complications of, threatening life 440

———————— condensation of air in meatus in treatment of 448

———————— condition of tympanum in . . 435

———————— constitutional treatment of . . 457

———————— course and results of . . . 439

———————— diagnosis of 440

———————— enlargement of perforation in . 447

———————— Eustachian catheter in treatment of 447

———————— Eustachian tube, state of, in . 427

———————— iodoform in treatment of . . 452

———————— *masseur*, Delstanche's, in treatment of 458

———————— measures for improving hearing-power in cases of . . . 457

———————— membrana tympani, state of, in 425, 432

———————— micro-organisms found in . . 431

———————— morbid appearances in . . . 424

———————— mortality from 423

———————— objective symptoms of . . . 430

———————— perforation of membrana tympani in 432

—————————— Shrapnell's membrane in . 435

———————— persons suffering from, a possible source of danger to others . . 458

———————— Politzer's method in treatment of 447

———————— prognosis of 442

———————— statistics of 423

———————— subjective symptoms of . . 428

———————— syringe in treatment of . . 444

———————— tinnitus as a symptom of . . 429

———————— treatment of 444

———————— tympanic irrigator (author's) in treatment of 446

———— communications of, with adjacent parts 30

———— comparative value of methods of inflating . . . 138

———— condition of, in fœtus 48

———— croupous and diphtheritic inflammation of . . . 600

———— diabetes as a cause of disease of 627

———— dimensions of 31

———— diseases of 333

———— external wall of 22

———— floor of 29

———— forms of disease of 334

———— functions of 59

———— influenza as a cause of disease of 614

———— inner wall of 27

PAGE

Middle ear, lining membrane of 45
——— malaria as a cause of disease of 625
——— measles as a cause of disease of 607
——— methods of inflating 116
——— movements of ossicles of 37
——— mumps as a cause of disease of 610
——— muscles of 40
——— ossicles of 35
——— pouches of 46
——— results of passage of air into 137
——— roof of 29
——— scarlatina causing disease in 603
——— small-pox causing disease in 624
——— syphilis as affecting 632
——— tuberculous disease of 628
——————— prognosis and treatment of 631
——————— symptoms and diagnosis of 630
——— typhus and typhoid as causing disease in 620
——— vessels and nerves of 48
——— walls of 22

Mirrors for reflecting light into meatus 81
——— Gardiner Brown's 82

Moos and Steinbrügge on aural polypi 495
——————— solution of acetate of lead, as an application to aural polypi 508

Mucous polypi of ear 492

Mumps, disorders of hearing connected with 610

Myringitis (*see* Membrana tympani, inflammation of) 259

Myringo-plastic operations 467

Myringotome for paracentesis of the membrane 351

Myxomatous polypi of ear 495

Nasal bougies, forms of 281
—— catarrh, acute 268
——————— symptoms and treatment of 269
—— douche, dangers attending use of 276
—— passages, examination of 107
—— polypus, treatment of 285
—— snare, Sir M. Mackenzie's, author's modification of 286
—— specula 107

Naso-pharynx, adenoid growths in 300
——————— chronic catarrh of 270
——————————— cauterisation in treatment of 281
——————————— connection between, and aural disease 273
——————————— douche for, dangers attendant on use of 276
——————————— insufflation in treatment of 279
——————————— nasal bougies for 281
——————————— spray-producer in treatment of 275
——————————— symptoms of 272

PAGE
Naso-pharynx, chronic catarrh of, treatment of 274
——— digital examination of 114
——— ——— author's finger-guard for 115
——— morbid growths in 298
Nausea and vomiting as symptoms of disease of internal ear . . 680
Necrosis of temporal bone 510
Negroes, size of meatus in 12
Nervous deafness, question as to existence of 669
——— treatment of, by induced current 756
Neuroses of the auditory nerve 735
New formations of external ear 222
——— in labyrinth and of auditory nerve 716
Noise as a cause of labyrinthine disease 673
Noises in the ears 743
Nose, pharynx, and naso-pharynx, diseases of, connected with affections of the middle ear 267
——— etc., examination of 106
Nunn's uvula scissors 297

Occupations as causes of aural diseases 71, 741
Odynphagia, method of relieving 295
Ointments, various, in treatment of chronic naso-pharyngeal catarrh 278
Optic neuritis in cerebral complications of ear disease . . . 567
Ossicles of tympanum 35
——— caries of 512, 521
——— excision of, in chronic adhesive catarrh . . 390
——— movements of 37
Otalgia, causes of 644
——— symptoms and treatment of 645
Othæmatoma of auricle 181
——— symptoms of 183
——— treatment of 184
Otitis media (*see* Middle ear, catarrh of, etc.).
Otoliths in labyrinth 653
Otophone, Maloney's, for deaf persons 770
Otorrhœa as a symptom 74
Ozæna, treatment of 283

Paget, Sir J., on congenital aural fistulæ 167
Pain as a symptom of aural diseases 73
Palate-tractors, forms of 111
Paracentesis of the tympanic membrane in acute middle-ear catarrh 351
——— ——— suppuration 417
——— ——— chronic middle-ear catarrh 365
Paracusis as a symptom of labyrinthine disease 675
——— following administration of certain medicines . . . 676
——— of Willis 359, 373, 737

PAGE
Parasitic inflammation of external meatus 211
—————— treatment of . . . 216
Pepsin and papain, application of, to tympanum in chronic adhesive catarrh . . 385
—————— in chronic middle-ear suppuration . 455
Perforation of membrane in chronic suppuration 432
—— persistent, of tympanic membrane 463
Perichondritis of auricle. 186
Pharyngeal openings of Eustachian tubes 113
—— tonsil 113
Pharyngitis, granular, symptoms and treatment of 295
Pharynx, examination of 108
Phlebitis and thrombosis of sigmoid sinus 576
Pneumatic speculum 89
Politzer, instruments for relief of deafness 770
—— method of injecting air through Eustachian tube . . . 117
—————— general results of . . 122
—————— modifications of . . 119
—————— occasional bad effects of 121
—— passage of bougies along Eustachian tube 143
—— pathological appearances in chronic adhesive catarrh . . 368
Polypi, aural 492
—— alcohol as an application to 507
—— causes of 495
—— caustic and astringent applications to 506
—— dangers connected with 500
—— description of 492
—— diagnosis of 500
—— galvano-cautery for removal of 505
—— histology of 492
—— symptoms caused by 499
—— treatment of 502
—— varieties of 492
—— Wilde's snare for removal of 503
Poultices and warm fomentations, caution as to use of, in aural affections 149
Powders, insufflation of, into external meatus and tympanum . . 155
Prussak's space in tympanum 46
Pyæmia as a result of middle-ear suppuration 586

Quinine, effect of, upon organ of hearing 671

Rarefaction of air in meatus, methods of 90, 458
Recruits, Austrian and Prussian regulations as to hearing-power of . 782
Reissner's membrane 658
Relapsing fever, aural complications in 406

PAGE
Rhinoscopy, anterior, parts seen in 107
———— posterior, method of effecting 109
———————— parts seen in 112
———————— tongue-depressors for 110
———————— use of palate-tractors in 111
———— requisites for 107
———— specula for 107
Rinne's experiment, use of, in chronic adhesive catarrh . . . 379
—————————— diagnosis of diseases of labyrinth . 686
—————————— testing bone-conduction . . . 102
Robertson, Dr. W., on co-existence of adenoid growths with cervical adenitis 305
Rohrer, Dr., on micro-organisms in chronic middle-ear suppuration . 431
Rüdinger, Prof., on folds in Eustachian tube 54
Rupture of tympanic membrane 250
Rutherford, Dr., on function of cochlea 665

Sarcoma of external ear. 225
———— labyrinth 717
Scarlatina, otitis media due to 603
———— treatment of otitis media due to 604
Schwabach, Dr., on plan of distinguishing between affections of sound-conducting apparatus and those of the labyrinth . 689
————— on use of Rinne's test in diagnosis of diseases of labyrinth 687
Schwalbe, Dr., on ceruminous glands of meatus 15
Sclerosis of middle ear (*see* Chronic adhesive catarrh). . . . 367
Scoop for removing cerumen and foreign bodies from meatus . . 83
Semicircular canals, description of 649, 651
——————— functions of 660
Sexton, Dr., on excision of stapes in chronic adhesive catarrh . . 392
————— tenotomy of tensor tympani in chronic adhesive catarrh 399
Shocks and noises as causing disease of internal ear 673
Shrapnell's membrane (*membrana flaccida*) 26
——————— perforation of, in acute suppuration of middle ear 410
——————————————— chronic——————— 435
——————— state of, in chronic adhesive catarrh . . . 374
Siebenmann, Dr., on parasites in external meatus 213
Siegle's speculum 89
Sigmoid sinus, phlebitis and thrombosis of 576
Simulated deafness, detection of 775
Skin-grafting after operations on mastoid process 551
Small-pox, aural affections connected with 624
Snare, Wilde's, for removal of aural polypi 503
Snell, Dr. H., on effects of compressed air on ear 255
Solutions, application of, to nose and naso-pharynx 275
Sonometer, Hughes', for testing hearing-power 95

PAGE

Sound-conducting and sound-perceiving apparatus 3
Sounds, bone-conduction of 99
———— Gardiner Brown's tuning-fork for testing 101
———— methods of testing 99
Specula for examination of ear, forms of 83
———— nose 107
Speculum, aural, Brunton's 83
———— Dalby's 86
———— introduction of 86
———— objects seen through 87
———— Siegle's 89
Speech as a test of hearing-power 97
Spray-producer, single ball, for treatment of chronic naso-pharyngeal catarrh 276
Stacke's operation for removal of ossicles through the meatus . . 524
Stapedius muscle 41
Stapes, description of 36
——— excision of, in chronic adhesive catarrh 392
Steiner, Prof., on semicircular canals in sharks 731
Subjective auditory sensations as symptoms of aural disease 75, 678, 743
———— causes of 744
———— difference between, and entotic noises 748
———— forms of 743
———— in chronic adhesive catarrh . . 372
———— prognosis of, and treatment of . . 751
Switzerland, deaf-mutism in 759
Symington, Dr., on measurements of external meatus . . . 11
———— meatus in new-born children 17
Symptoms of aural diseases 73
Syphilis, risk of conveying, by Eustachian catheter 125
Syphilitic affections of external ear 218
———— internal ear 720
———— middle ear 632
Syringe for ear, with bayonet joint for nozzles 144
——— use of, in treatment of chronic naso-pharyngeal catarrh . 277
Syringing ear, method of 147
———— symptoms occasionally caused by 148

Taste, perversions of, in caries and necrosis of temporal bone . . 515
Temperature in cases of cerebral abscess 568
Tensor tympani muscle 40
———— division of tendon of, for chronic adhesive catarrh 398
———— Kessel on indications for tenotomy of . . 399
Teuber, method of detecting simulated deafness 777
Throat, von Tröltsch's method of gargling 299
Tinnitus (*see* Subjective sensations).
Tongue-depressor, author's 110

PAGE

Tongue-depressor, forms of 109
Tonsillotome, Mackenzie's modification of Physick's 288
Tonsillotomes, dimensions of author's set of 288
Tonsillotomy, arrest of hæmorrhage after 293
—— operation of 290
Tonsils, enlarged, treatment of 288
Toynbee, Mr., artificial tympanic membrane 469
Treatment of aural diseases, methods of 144
Tuberculosis, general, as a result of middle-ear suppuration 590
Tuberculous disease of middle ear 628
—— prognosis and treatment of 631
—— symptoms and diagnosis of 630
Tuning-forks as tests of hearing-power 98
—— for testing bone-conduction 99
—— Gardiner Brown's, fitted with tube and ear-piece, as used by author 101
—— number required 98, 685
—— Rinne's experiment with 102, 686
—— use of, in diagnosis of labyrinthine diseases 685
—— Weber's experiment with 99
Turbinate body, inferior, hypertrophy of posterior extremity of 284
Tympanic irrigator (author's), use of, in chronic middle-ear suppuration 446
Tympanum, carious destruction of walls of, causing profuse hæmorrhage 642
—— hæmorrhage in 639
—— treatment of 640
—— with perforation or rupture of membrane 641
—— injuries of 635
—— involving large blood-vessels 642
—— symptoms of 636
—— treatment of 640
—— openings (dehiscences) in roof of 29, 638
—— watery discharge from ear in injuries of 637
(*See also* Middle ear, etc.)
Typhoid fever, aural affections connected with 621
Typhus —— 620

Urbantschitsch, Prof., on passage of bougies along Eustachian tube 140
—— treatment of deaf-mutism by "acoustic gymnastics" 767
Utricle and saccule, histology of 652
Uvula, importance of, in formation of vowel-sounds 304
—— instrument for scarifying 294
—— scissors, Nunn's 297

Valsalva, method of, for inflating tympanum 116
—— advantages of 117

PAGE
Valsalva, method of, for inflating tympanum, caution as to use of . 116
Vapours and gases, injections of, through Eustachian tube . . 159
Vertigo as a symptom of labyrinthine disease 678
Vestibule, description of 649
Voltolini, Dr., cases of otitis labyrinthica 595, 679

Waller, Dr., on function of cochlea 666
Warner, Dr. Francis, statistics of deaf-mutism 760
Watch, method of using, to test hearing-power 91
——— use of, for testing bone-conduction 104
Weber's experiment, use of, in testing bone-conduction . . . 99
Weber-Liel, method of applying electricity to ear 757
Whistle, Galton's, for testing hearing-power 95, 691
Wilde's snare for removing aural polypi 503
Wilks, Sir S., on pathology of Ménière's disease 728
Woakes, Dr. ——————————— 729
Word-deafness, lesions in temporal gyrus causing 667

Yearsley, Mr., artificial tympanic membrane 469

Zaufal on micro-organisms in acute middle-ear catarrh . . . 339
——————————————— suppuration . . 404
Zuckerkandl, Dr., on variations in structure of mastoid cells . . 63

NAME	DATE DUE

34705